H. Residential Water Heating and Lighting

(Editor's Note: Appendix H is a combination of the Lighting portion of Chapter 2 and all of Chapter 6, Water Heating, from the **Residential Manual**. References found in this appendix are a part of the **Residential Manual**.)

Water Heating Summary

This chapter explains the relationship of water heating energy to the overall *Energy Efficiency Standards* (hereafter standards) compliance for a building. The Introduction briefly summarizes the *Water Heating Calculation Method* and explains when calculations and forms are required. This is followed by a more detailed discussion of the Basic Approach to the Method and step-by-step instructions on how to complete the water heating forms. Case studies outline the requirements for common and unusual water heating systems. Separate calculations and forms are explained for hydronic space and water heating systems. The chapter concludes with detailed descriptions of system components and installation criteria.

Chapter Overview:

Applicable sections of the California Code of Regulations, Title 24, Part 6: §150(j), 151(b), 151(f)8, 152.

Introduction

Water heating energy use is important because it accounts for about a quarter of residential energy consumption, as illustrated in Figure 6-1. This is the same percentage used statewide for residential space heating, and six times the amount used for residential cooling. Water heating energy may be an even higher percentage of the total energy consumption in small residences with lower space heating and cooling requirements.

Figure 6-2 shows the general flow of energy from the fuel source through the water heating system to the end use in the building. *Total energy in* is a combination of source energy plus any auxiliary inputs, which equals total energy out. *Total energy out* includes energy lost through electric power generation and transmission to the residence, water heater recovery efficiency and standby loss, distribution system losses and finally, hot water delivered to fixtures and appliances (see *Source Energy* in the *Glossary*).

Figure 6-1– Largest Residential Energy End

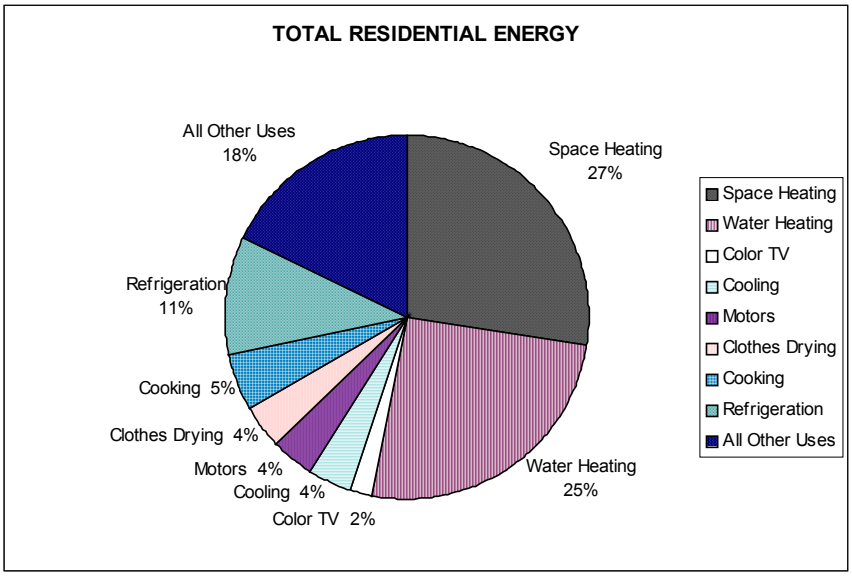
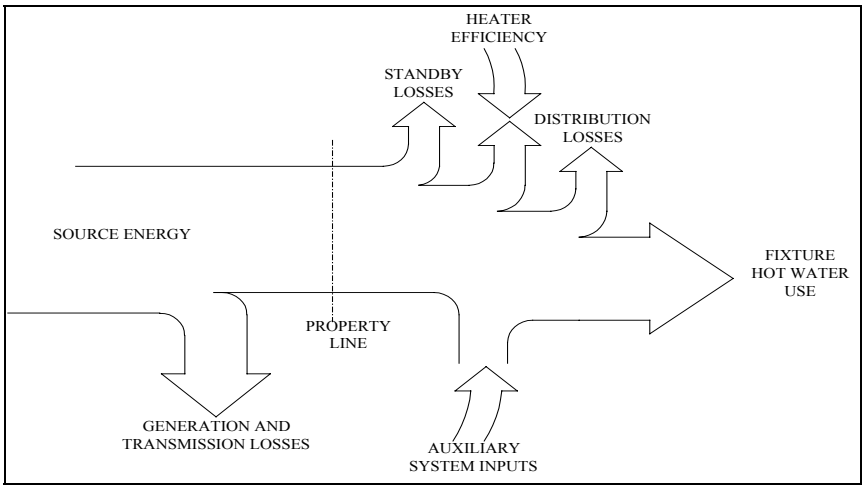


Figure 6-2– Water Heater System Energy Flow Diagram



Energy Factor is a measure used for *Heater Efficiency* for most water heaters used in single family dwellings and includes standby losses, recovery efficiency (the ratio of energy output used to heat the water divided by energy input), and the tank volume. More efficient water heaters have a higher EF.

Standby Loss accounts for energy lost while storing heated water. It includes heat losses through the water heater tank walls, fittings and flue, if any, plus any pilot light energy. Standby loss depends on the design and insulation of the water heater, as well as the difference between the temperature of the water and that of the air around the tank. Water heating energy use can be reduced by decreasing standby loss. This can be done by selecting a more efficient heater.

The water heater efficiency rating for small water heaters used in the water heating calculation method is the ***Energy Factor*** (EF) which combines tank volume, internal insulation, recovery efficiency and standby loss. The higher the EF the more efficient the water heater.

Recovery energy is the energy used to heat water, including the inefficiency (or efficiency loss) of the heater.

Recovery load is the amount of energy in hot water that the water heater needs to provide. It includes only the energy in the hot water that is used by the building occupant and the distribution losses.

Standby loss is over a quarter of a gas storage type water heater system's total energy use. When the system fuel is natural gas, there are no generation or transmission losses as are associated with electricity. Fuel type is very important in determining water heating energy use. While natural gas, LPG or oil can be burned directly to heat water, electricity is typically generated in a power plant far from the residence and then transmitted over power lines to the final end use. Approximately two thirds of the source energy used to generate electricity is lost in this process.

Any electric water heating system must automatically account for the inefficiency of the fuel type. Standard electric water heaters are not considered energy efficient for this reason.

Electric heat pump water heaters, however, are closer to the efficiency of typical gas systems, because they use the outdoor air as a heat source in heating water (see *Heat Pump* in the *Glossary*).

See Table 6-1A and Section 6.6 for more information on water heater types.

All water heating systems must meet the mandatory measures explained in Chapter 2, and all water heaters installed in California must be certified to the Commission (see Section 2.6 and 1.6). Several values that are needed in the water heating method are listed in this directory.

Water Heating Calculation Method Compliance/ Plan Check

The water heating calculation method estimates the amount of source energy used by any water heating system (the *Proposed Energy Use*) and compares it to the energy budget for water heating established by the standards (the *Standard Energy Use*).

Sections 6.2 and 6.3 give detailed information and instructions on using the water heating calculation method. Section 6.3 includes blank copies of the various forms and the tables used in the calculations.

The calculation method looks at three components of each water heating system:

- Water Heater Type
- Auxiliary Input (nondepletable energy sources)
- Distribution System Type

Water Heater Type

Water heater types that can be analyzed using the water heating calculation method are:

- Standard Water Heater
- Storage Gas
- Large Storage Gas
- Storage Electric
- Storage Heat Pump
- Instantaneous Gas

- Instantaneous Electric
- Indirect Gas
- Oil-Fired

See Table 6-1A for brief descriptions of each water heater type and Section 6.6 for more detailed descriptions plus installation criteria.

Auxiliary Inputs

Auxiliary inputs are other energy sources that contribute to overall water heating. The calculation method allows water heating credits for two auxiliary input types that save energy by using nondepletable energy sources:

- Passive and Active Solar Water Heaters
- Wood Stove Boilers

See Table 6-1B for brief descriptions of each auxiliary input type and Section 6.6 for more detailed descriptions plus installation criteria.

Table 6-1A – Summary of System Components: Water Heaters

Water Heaters and Related Components	***Description***
Standard Water Heaters	Storage gas water heaters, 50 gallons or less (R-12 external insulation is a mandatory requirement for any water heater with an EF of less than 0.58).
Storage Gas	A gas water heater with a storage capacity of two gallons or more and a rated input of 75,000 Btu/hr or less.
Large Storage Gas	A storage gas water heater with greater than 75,000 Btuh input.
Storage Electric	An electric water heater with a storage capacity of two gallons or more.
Storage Heat Pump	An electric water heater that uses a compressor to transfer thermal energy from one temperature level to a higher temperature level for the purpose of heating water.
Instantaneous Gas	A gas water heater that heats water on demand rather than storing preheated water in a tank. Manufacturer's specified storage capacity must be less than two gallons.
Instantaneous Electric	An electric water heater that heats water on demand rather than storing preheated water in a tank. Manufacturer's specified storage capacity must be less than two gallons.
Indirect Gas	A water heater consisting of a storage tank with no heating elements or combustion devices, connected via piping and recirculating pump to a heat source typically consisting of a gas or oil fired boiler.

Table 6-1B – System Component Descriptions: Auxiliary Inputs

Auxiliary Systems	***Description***
Passive Solar Water Heaters	Systems which collect and store solar thermal energy for domestic water heating applications and do not require electricity to recirculate water through a solar collector.
Active Solar Water Heaters	Systems which collect and store solar thermal energy for domestic water heating applications requiring electricity to operate pumps or other components.
Wood Stove Boilers	Wood stoves equipped with heat exchangers for heating domestic hot water (see Figure 6-8).

Distribution System

The water heating *distribution system* is the configuration of piping, pumps and controls which regulates delivery of hot water from the water heater to all end uses within the building. The water heating method gives credits for especially energy-efficient distribution systems, such as non-recirculating systems with pipe insulation, while assigning penalties for less energy-efficient systems, such as continuous recirculation systems with no controls (see Table 6-3).

Distribution systems that may be analyzed are:

- Standard Distribution System
- Point of Use
- Hot Water Recovery
- Pipe Insulation
- Parallel Piping
- Recirculation: Continuous
- Recirculation: Temperature Controlled
- Recirculation: Time Controlled
- Recirculation: Time & Temperature Controlled
- Recirculation: Demand Pumping
- Combined Credits

Table 6-1C gives brief definitions of all of the distribution system types listed above, while Section 6.6 describes the systems in more detail and explains any required installation criteria.

When are Water Heating Forms Required?

Water heating forms must be provided only for non-standard systems that are not listed in Chapter 3 (for Prescriptive Packages). Table 6-2 summarizes when water-heating forms are required within the different compliance approaches.

Standard Water Heating Systems

If a proposed water heating system in a single family residence has no more than one *standard water heater* (as defined below) with a *standard distribution system*, then the water heating system need not be analyzed, but may be assumed to meet the water heating energy budget without requiring any additional forms or calculations. Compliance is demonstrated by simply listing the water heater on the Certificate of Compliance (CF-1R) Form.

The following water heater type is considered a *standard water heater:* storage gas water heater, 50 gallons or less, with a standard distribution system.

Note: Any storage heat pump water heater, 50 gallons or less, with an EF of at least 1.8 in Climate Zones 1-15, or at least 2.6 in Climate Zone 16, and a standard distribution system meets the water heating energy budget.

Table 6-1C – System Component Descriptions: Distribution Systems

Distribution Systems	***Description***
Standard	Standard system without any pumps for distributing hot water
Point of Use	System with no more than 8 feet horizontal distance between the water heater and hot water fixtures, except laundry. (Not used with central systems in multi-family buildings.)
Hot Water Recovery	System which reclaims hot water from the distribution piping by drawing it back to the water heater or other insulated storage tank. (Not used with central systems in multi-family buildings.)
Pipe Insulation	R-4 (or greater) insulation applied to 3/4 inch or larger, non-recirculating hot water mains in addition to insulation required by the standards, §150(j) (first five feet from water heater on both hot and cold water pipes).
Parallel Piping	Individual pipes from the water heater to each point of use.
Recirculation: Continuous	Distribution system using a pump to recirculate hot water to branch piping though a looped hot water main with no control of the pump, such that water flow is continuous. (Not used with instantaneous water heaters.) Pipe insulation is required.
Recirculation: Temperature	Recirculation system that uses temperature controls to cycle pump operation to maintain recirculated water temperatures within certain limits. (Not used with instantaneous water heaters.) Pipe insulation is required.
Recirculation: Time	Recirculation system that uses a timer control to cycle pump operation based on time of day. (Not used with instantaneous water heaters or with central systems in multi-family buildings.) Pipe insulation is required.
Recirculation: Time/Temp	Recirculation system that uses both temperature and timer controls to regulate pump operation. (Not used with instantaneous water heaters or with central systems in multi-family buildings.) Pipe insulation is required.
Recirculation: Demand	Recirculation system that uses brief pump operation to recirculate hot water to fixtures just prior to hot water use when a demand for hot water is indicated. (Not used with instantaneous water heaters or with central systems in multi-family buildings.)
Recirculation/Demand w/ Hot Water Recovery	Combined system consisting of Recirculation: Demand and Hot Water Recovery (Not used with instantaneous water heaters or with central systems in multi-family buildings).
Recirculation/Demand w/ Pipe Insulation	Combined system consisting of Recirculation: Demand and Pipe Insulation (Not used with instantaneous water heaters or with central systems in multi-family buildings).

A *standard distribution system* is one which does not incorporate a pump to recirculate hot water, and does not take credit for any special design features. A distribution system normally eligible for energy credits, such as one with pipe insulation, may be modeled as standard (i.e., no credits) to avoid water heating calculations.

See Section 6.6 for more detailed descriptions of standard water heaters and distribution systems, including installation criteria.

Table 6-2 – When Are Water Heating Forms Required?

	Water Heating System Type		
Compliance Method	Standard	Pre-Calculated Non-Standard	Other Non-Standard
Prescriptive Packages	No	No [1,2]	Yes[4]
Performance Method[4]	No	n/a	No 1,4

Notes:

1 No water heating forms are required, except to document solar collector systems and/or wood stoves.

2 Pre-calculated non-standard systems are listed in Chapter 3.

3 Approved programs perform water heating calculations internally; forms need not be submitted.

See Table 6-4 and Table 6-5 for a summary of water heating forms and compliance scenarios.

Pre-Calculated Non-Standard Systems

To simplify compliance with the prescriptive packages the Commission has developed lists of non-standard water heating systems that may be used without submitting water heating calculations. Systems pre-calculated and shown to meet or exceed the efficiency of a standard system are found in Table 3-13 through Table 3-17.

Approved Computer Methods

Approved computer programs perform water heating calculations internally, making water heating compliance forms unnecessary. However, other documentation may be required to support water heating credits for auxiliary inputs or other unique system components used for compliance.

Water Heating Calculations And Energy Compliance

The basic structure of the water heating calculation method is to:

(1) Calculate the *Proposed Energy Use* of the proposed water heating system
(2) Determine the *Standard Energy Use* (the energy budget)
(3) Compare the *Proposed Energy Use* to the *Standard Energy Use*

Prescriptive Packages

When demonstrating energy compliance for a building using the Prescriptive Packages, the proposed energy use for a water heating system must be less than the standard energy budget (Section 3.7). This requirement may be met by:

- Installing a standard water heating system;
- Installing an approved non-standard system as listed in Table 3-13 through Table 3-17; or,
- Completing the calculations and forms contained in Section 6.3 to verify that the proposed energy use is less than the standard energy use.

Performance Methods

When demonstrating energy compliance for a building using an approved performance method, the building's total (combined) space conditioning and water heating energy consumption cannot exceed the sum of the total space conditioning and water heating energy budgets (Section 4.2).

When using an approved computer program, water heating compliance is calculated internally within the program.

If the building has a standard water heating system as defined above, the Proposed Energy Use is equal to the Standard Energy Use in the performance methods.

Water Heating Calculations For Additions

There are three typical situations for water heating systems in building additions:

1. The addition uses the existing water heating system. No new water heater is added. If no new water heater is added, the addition may be analyzed by itself without requiring water heating calculations. If the addition is analyzed using the existing-plus-addition method (performance), then either the existing water heating system may be modeled as is or it may be assumed to be a standard water heating system (see Section 6.3 - use the same modeling assumptions for all calculations).

2. A new water heater, installed to replace the existing water heater, serves the entire existing building plus the addition, and there is no increase in the number of water heaters in the building. In this case

water heating calculations are not required because the total number of water heaters does not increase. The new water heater serves as a replacement; for the purpose of compliance analysis, it may be assumed to be a standard water heater.

3. A new water heater (or heaters) is added with the addition, resulting in an increase in the number of water heaters (see below).

§ 152(a), Exception No. 3

Additions that Increase the Total Number of Water Heaters

If the addition will increase the total number of water heaters in the building, one of the following types of water heaters may be installed to comply with Section 152(a)1. or Section 152(a)2.A, and Section 152 (c):

(1) A gas storage non-recirculating water heating system that does not exceed 50 gallons capacity; or

(2) If no natural gas is connected to the building, an electric storage water heater that does not exceed 50 gallons capacity, has an energy factor not less than 0.90; or

(3) A water heating system determined by the Executive Director to use no more energy than the one specified in (1) above; or if no natural gas is connected to the building, a water heating system determined by the Executive Director to use no more energy than the one specified in (2) above.

For prescriptive compliance with Section 152(a)1., the water heating systems requirement in Section 151(f)8. shall not apply. For performance compliance for the addition alone, only the space conditioning budgets of Section 151(b)2. shall be used; the water heating budgets of Section 151(b)1. shall not apply. The performance approach for the existing building and the addition in Section 152(a)2.B may be used to show compliance, regardless of the type of water heater installed.

When there is an increase in the number of water heaters, the addition may be analyzed using any of the compliance approaches under certain conditions. Addition alone compliance may be used if:

(a) The additional water heater is either a 50 gallon or less, gas storage, nonrecirculating water heater or equivalent (see Section 7.2) that also meets the mandatory requirements (see Chapter 2);

(b) The home does not have natural gas available and the additional water heater is either a 50-gallon or less electric water heater with an EF of 0.90 or greater or equivalent (see Section 7.2);

(c) If the conditions in (a) or (b) are met, water heating calculations are not required with any of the compliance approaches, and no credit or penalty is allowed. Computer compliance calculations will show proposed energy use for water heating to be equal to standard energy use.

Existing-plus-addition compliance may be used when a new water heating system is proposed which is not described in (a) and (b) above, is not found in Section 7.2, or to take credit for a more efficient water heating system.

See Examples 6-8, 6-9 and 6-12 in Section 6.4, and Chapter 7 for more information on compliance of water heaters associated with additions.

Water Heating Inspection

Check that the number and types of water heater systems installed, as indicated on the CF-6R and check to see that this corresponds to the approved CF-1R. The distribution system is also significant and must correspond to plan specifications. For example:

- If the plans indicate the presence of a hot water recovery system, it must be installed.
- If a recirculation system is installed, verify that it was accounted for in the compliance documentation (CF-1R) and check for any required controls (e.g., demand pump, timer).
- If a point of use credit is specified, the water heater must be no further than 8 feet from all hot water outlets (excluding washing machines).

The chart below summarizes the different distribution system types and lists whether each one is a credit or a penalty as compared with the standard distribution system.

Verify the make and model number of the installed water heater unit matches that listed on the Installation Certificate (CF-6R).

If the water heater has an EF of less than 0.58, an R-12 water heater blanket is required (internal insulation cannot be used to satisfy this mandatory requirement). For water heaters with 0.58 EF or higher, no insulation blanket is required. The blanket should be securely attached around the water heater. The top of the water heater should not be insulated and a cutout in the blanket should be provided for combustion air intake.

Table 6-3 – Water Heating Distribution System Credits and Penalties

Distribution System	***Credit or Penalty***
Hot Water Recovery	Credit
Point of Use	Credit
Pipe Insulation	Credit
Parallel Piping	Credit
Recirculation:	
No Control	Penalty
Time	Penalty
Temperature	Penalty
Time/Temperature	Credit
Demand	Credit

Basic Approach

§151(b)1

Water Heating Budget

Water heating budgets. The budgets for water heating systems are those calculated from:

Equation 6-2

ANNUAL WATER HEATING BUDGET (AWB):
For dwelling units less than 2500 ft²:

$$AWB\ (kBtu/yr.\text{-}ft^2) = \frac{(16370) + 4.85}{CFA}$$

For dwelling units equal to or greater than 2500 ft²:

$$AWB\ (kBtu/yr.\text{-}ft^2) = \frac{(26125)}{CFA}$$

Where CFA = the building's conditioned floor area in square feet.
The annual water heating budget calculated from Equation No. 1-N may be met by either:
A. Calculating the energy consumption of the proposed water heating system using an approved calculation method without an external insulation wrap or
B. Installing any gas storage type non-recirculating water heating system that does not exceed 50 gallons of capacity, and that meets the minimum standards specified in the Appliance Efficiency Standards.

Note: Storage gas water heaters with an energy factor of less than 0.58 must be externally wrapped with insulation having an installed thermal resistance of R-12 or greater in accordance with §150(j).

As outlined in Section 6.1, the water heating method involves the calculation of the *Proposed Energy Use* of the proposed system, and the determination of the *Standard Energy Use* for the dwelling unit being analyzed (see form DHW-1).

The standard water heating energy use per dwelling unit is dependent on the total conditioned floor area

of the dwelling unit. Allowable water heating energy use per dwelling unit increases with an increase in floor area. However, 26,125 kBtu/yr-unit is the maximum standard water heating energy use for dwelling units larger than 2,500 square feet (§151(b)1 of the standards).

Standard energy use is assumed to be climate-independent. It is based on the energy use of a federally rated minimum efficiency 50 gallon gas water heater (EF 0.525) with a standard distribution system (see Section 6.6).

Presented as a hand method in this chapter, water heating calculations use a series of forms and tables included at the end of Section 6.3. The forms and tables used are selected according to the specific proposed water heating system. Tables 6-3 and 6-4 summarize the forms as well as their application in a range of compliance situations.

The water heating method can be used to analyze water heating energy use of:

- A specific single dwelling unit;
- An average dwelling unit in a multi-family building; or,
- Each different dwelling unit in a multi-family building.

Note: When multi-family water heaters are *shared* by more than one dwelling unit, compliance must be based on the average of the square feet of the dwelling units served by each (different) shared water heater.

Table 6-4 – Summary of Water Heating Forms

Number	***Name/Function***	***Application***
DHW-1	Water Heating Worksheet	Non-standard water heating system
DHW-2A	Water Heating for Single Family w/ Multiple Heaters	Single-family dwelling unit with more than one water heater
DHW-2B	Water Heating for Multi-Family	Multi-family building
DHW-3	Large or Indirect Water Heater	Large Storage Gas or Indirect Gas heater Worksheet(see Section 6.6)
DHW-4	Removed (incorporated into DHW-1)	Solar and wood heating calculations
DHW-5	Combined Hydronic Space and Water Heating	Hydronic system serving both space heating and water heating (see Section 6.5)

Table 6-5 – Summary of Compliance Scenarios

Compliance Scenario		***Forms Submitted***
a.	One Standard System Per Dwelling Unit	None
b.	Pre-Calculated System (see Chapter 3)	None
c.	One Non-standard System Per Dwelling Unit(other than pre-calculated systems)	DHW-1
d.	Single Family Dwelling w/Multiple Heaters(other than pre-calculated systems)	DHW-1, DHW-2A
e.	Multi-Family Building	DHW-1, DHW-2B
f.	Solar or Wood Stove (Auxiliary Input)	DHW-1
g.	Combined Hydronic Space and Water Heating	DHW-5
h.	Additions (see Chapter 7)	Same as a, b, c, d, e, f or g above

The compliance methodology has three steps:

1. Determine the *Adjusted Recovery Load* to be satisfied by the water heating system. The *Standard Recovery Load* (from Table 6-6) may be modified by *distribution piping system credits or penalties* (from Table 6-3) and/or a *solar energy credit* (from DHW-1).
2. Determine the *Proposed Energy Use* of the water heating system. The *Basic Energy Use* (from Table Table 6-7 according to heater type) may be modified by a *wood stove boiler credit* (from DHW-1).
3. Determine the *Standard Energy Use* of the dwelling unit(s) (from Table 6-6).

Water heating compliance depends on a comparison of the Proposed Energy Use and the Standard Energy Use:

- Prescriptive: The Proposed Energy Use must be less than or equal to the Standard Energy Use for compliance of the water heating system.

- Performance Methods: The difference between Proposed and Standard Water Heating Energy Use is either a *credit* resulting in a *lower kBtu/sf-yr* of total proposed energy use, or a *penalty* resulting in a *higher kBtu/sf-yr* of total energy use.

Water Heating in the Performance Methods

Using the performance approach, *energy tradeoffs* can be made between water heating and space conditioning energy use. If the proposed water heating energy use is greater than the standard energy use, the water heating system and building comply as long as the total proposed design energy use, in kBtu/sf-yr, is the same or less than the total standard design energy budget using a computer method as explained in Chapter **5**.

Instructions, Forms & Tables

The instructions presented in this part provide a step-by-step description for each worksheet and form. To see completed sample worksheets for different water heating systems, see Section 6.4. For an overview of which forms apply to which compliance scenarios, refer to Table 6-4.

The worksheet for Combined Hydronic Space and Water Heating, DHW-5, is contained in Section 6.5. Heater type data is contained in the Commission's listing of certified water heaters. Data on water heaters, for use with a database program is also available from the Commission's Web site at: www.energy.ca.gov/appliance

DHW-1, Water Heating Worksheet

Complete the DHW-1 form whenever there is a non-standard water heating system (see Sections 6.1 and 6.6). You may calculate up to three different heater types per sheet. If you have more than three different types, use additional copies of the worksheet.

The section of the worksheet entitled *Energy Use Calculation* refers to tables included at the end of this part.

Title Block

- Enter **Project Title** and **Date**.
- Enter the **Number of Different Water Heater Types** (this value may not necessarily be the same as the *total* number of individual water heaters in the building.)
- Enter the **Total No. of Water Heaters**.
- Enter the total **Conditioned Floor Area (CFA)** of the dwelling unit, in square feet. When multi-family water heaters are *shared* by more than one dwelling unit, compliance must be based on the average of the square feet of the dwelling units served by each (different) shared water heater. Enter this average dwelling unit CFA here.

Heater Type Data

For each column, enter the heater number (e.g., "Heater #_1_ Data".) To identify which water heater on the plans matches these calculations.

A. Indicate the **Water Heater Type**. For a full listing of heater type descriptions and installation criteria, see Section 6.6. If the water heater is part of a hydronic system, see Section 6.5.

Note: Oil-fired water heaters are considered gas water heaters for the purpose of the water heating calculations.

List the Manufacturer.

C. List the Model No.

The next set of values (lines D, E, F and G) must be taken from the Commission's listing of Certified Water Heaters.

D. Enter the Energy Factor. If Indirect Gas or Large Gas Storage water heater, leave blank.
E. Enter the actual capacity of the heater in Gallons.
F. For Instantaneous Gas heater type, enter Pilot Btu/hr.
G. For Instantaneous Gas heater type only, enter Thermal (Recovery) Efficiency (also used on form DHW-3).

H. Renewable energy sources such as solar or a wood stove are considered Auxiliary Input to the system. Indicate with a checkmark if either applies. For a full description of auxiliary inputs, see Section 6.6.
I. Indicate the Distribution System. For a full listing of distribution descriptions and installation criteria, see Section 6.6. If the distribution system is part of a hydronic system, see Section 6.5.

Energy Use Calculation

All values entered in lines 1a, 1b, 1d, 1e, 2a, 2c, 2d and 3 are in million Btu/year per dwelling unit (MBtu/yr-unit).

1a. Enter the **Standard Recovery Load** from Table 6-5 based on the total conditioned floor area of the dwelling unit.
1b. For a "Standard" distribution system, enter zero (0).

For other distribution system types, select **Distribution Credit** (+) or **Penalty** (-) from Table 6-6A or 6-6B based on standard recovery load (line 1a).

Pipe insulation credit can only be taken with nonrecirculating systems and demand recirculating systems.

1c. If there is a solar Auxiliary Input (line H), then use the conditioned floor area and a solar energy factor to select the **Solar Fraction** from Table 6-8. Otherwise, enter zero (0).

All solar water heating devices must be Solar Rating and Certification Corporation (SRCC) rated. A pre-approved solar water heating system includes the collectors and water heater. The SRCC may be contacted at:

Solar Rating and Certification Corporation
C/o FSEC, 1679 Clearlake Road
Cocoa, FL 32922-5703
(407) 638-1537
(407) 638-1010 (FAX)

1d. Multiply the Standard Recovery Load (Line 1a) with the Solar Fraction (Line 1c) to calculate the **Solar Energy Credit**.
1e. Subtract credits to calculate the **Adjusted Recovery Load** (subtract lines 1b and 1d from line 1a). Note that when line 1b is negative, line 1d increases.
2a. Based upon the Water Heater Type (line A), find the **Basic Energy Use** as follows:

Storage Gas	Table 6-7A
Storage Electric	Table 6-7B
Storage Heat Pump	Table 6-7C
Instantaneous Gas	Table 6-7D
Instantaneous Electric	Table 6-7D
Indirect Gas	DHW-3
Large Storage Gas	DHW-3

The tables use values listed on this worksheet such as Energy Factor (line D), Adjusted Recovery Load (line 1e), Pilot Btu/hr and Recovery Efficiency.

Note: No interpolation is allowed in Table 6-7. Go into the rows and columns in those tables using the table values closest to the actual values.

2b. If there is a wood stove Auxiliary Input (line H), determine the **Wood Stove Boiler Credit Factor** from Table 6-9. Otherwise, enter zero (0).

Wood Stove Boiler credit factors in Table 6-11 vary by climate zone and may be used to compute the wood stove boiler credit with or without a recirculating pump. DHW-1 must be completed through line 2a before WSB credit is computed.

Note: As tabulated in Table 6-11, the credit for Wood Stove Boilers with recirculating pumps is 90 percent of the credit without pumps based on a base case 85 watt pump applied to a 1700 ft^2 house and adjusted for electric source energy.

2c. Multiply the Basic Energy Use (Line 2a) with the Wood Stove Boiler Credit Factor (Line 2b) to calculate the **Wood Stove Boiler Credit**.
2d. Subtract the Wood Stove Boiler credit to calculate the **Proposed Energy Use** (subtract line 2c from line 2a).

Standard Energy Use

3. Find the **Standard Energy Use** from Table 6-5 using the total conditioned floor area of the dwelling unit. Enter the value on line 3.
4. In the prescriptive compliance approach (Section 3.7), *the proposed water heating system complies if line 2d is less than or equal to line 3*.

DHW-2A, Water Heating for Single Family with Multiple Heaters

If you are completing the DHW-1 form for a single family unit with more than one water heater, you must also complete the DHW-2A form.

Title Block

Enter **Project Title** and **Date**.

Single Family Project Data

1. Enter the **Number of different water heater types** (this may not necessarily be the same as the *total* number of water heaters in the building.)
2. Enter the **Total conditioned floor area** of the dwelling unit.

3a, 3b & 3c.

Enter the **Number of Heaters** for each **Heater Number**, **Manufacturer** and **Model Number** listed on DHW-1.

4. The **Total Number of Water Heaters** is the sum of lines 3a, 3b and 3c.
5. Enter the **Standard Recovery Load** from Table 6-5 based on line 2, total conditioned floor area.
6. Calculate and enter the **Recovery Load per heater**, which is line 5 divided by line 4. Enter this value on DHW-1, line 1a, for each heater type. Complete DHW-1 calculations through line 2d for each heater type.
7. Calculate and enter the **Proposed Energy Use** for **Heater #1**, which is DHW-1 Heater #1 line 2d times line 3a.
8. Calculate and enter the **Proposed Energy Use** for **Heater #2**, which is DHW-1 Heater #2 line 2d times line 3b.
9. Calculate and enter the **Proposed Energy Use** for **Heater #3**, which is DHW-1 Heater #3 line 2d times line 3c.
10. Calculate and enter the **Total Proposed Energy Use**, which is the sum of lines 7, 8 and 9.
11. Enter the **Standard Energy Use** from Table 6-5 using line 2, total conditioned floor area.

Compliance

12. In the prescriptive compliance approach (see Chapter 3), the proposed water heating system complies if line 10 is equal to or less than line 11.

DHW-2B, Water Heating for Multi-Family

Complete the DHW-2B form for any multi-family project. The DHW-1 worksheet must also be completed whenever the DHW-2B form is submitted.

Title Block

Enter **Project Title** and **Date**.

Multi-Family Project Data

1. Enter the Number of dwelling units.
2. Enter the Total conditioned floor area of the building.
3. Calculate and enter the Average floor area per dwelling unit, which is line 2 divided by line 1.
4. Indicate which analytical method is used to calculate Proposed Energy Use: Average Dwelling Unit or Individual Dwelling Unit. For "Individual Dwelling Unit" analysis, complete only lines 1 through 5, and attach a DHW-1 form with a Heater # for each individual unit.
5. Indicate which System configuration is being installed in the building: Individual Heaters (one per dwelling unit) or Shared Heaters (multiple dwelling units per heater).

If Individual Heaters, follow instructions for lines 9a through 11a.

If Shared Heater(s), complete lines 9b-13b, and follow instructions on line 13b.

6a, 6b, 6c & 6d.

Enter the **Number of Heaters** for each **Heater Number**, **Manufacturer** and **Model Number** listed. For Individual Heaters, also enter the volume in **Gallons** for **Each** heater, and for the **Total** number of heaters of that type; enter the **Energy Factor** for **Each** heater, and the **Total** value (which is the number of heaters times the EF). Enter the Thermal (Recovery) Efficiency for each heater and the Total value (number of heaters time the Thermal Efficiency.

7a. Enter the **Total** number of heaters, which is the sum of lines 6a, 6b and 6c.

The following items (lines 7b, 7c, 7d, 8a and 8b) are calculated only for Individual Heaters.

7b. Enter the **Total** gallons of all heaters.

7c. Enter the **Total** of the Energy Factors.

7d Enter the Total of the Thermal Efficiencies.

8a. Calculate and enter the **Average** gallons per heater, which is line 7b divided by line 7a.

8b. Calculate and enter the **Average** Energy Factor per heater, which is line 7c divided by line 7a.

8c. Calculate and enter the Average Thermal Efficiency per heater, which is line 7d divided by line 7a.

Individual Heaters

9a. Transfer the value from line 8a to DHW-1 line E (gallons).

10a. Transfer the value from line 8b to DHW-1 line D (Energy Factor).

11a. Transfer the value from line 8c to DHW-1 line G (Thermal Efficiency)

12. Check compliance on DHW-1 for average dwelling unit and average water heater.

Shared Heater(s)

9b. Calculate and enter the **Average Unit Recovery Load**, which is DHW-1 line 1e.

10b. Calculate and enter the **Total Adjusted Recovery Load**, which is line 1 times line 9b.

11b. Enter the **Basic Energy Use** from Table 6-7, or from DHW-3 line 9 based on line 10b.

12b. Calculate and enter the **Average Unit Building Energy Use**, which is transferred from DHW-1 line 2a.

13b. Verify compliance on DHW-1 for average dwelling unit.

14. In the prescriptive compliance approach (see Chapter 3), *the proposed water heating system complies if DHW-1 line 2d is less than or equal to DHW-1 line 3*.

DHW-3, Large Storage Gas or Indirect Gas Worksheet

Complete the DHW-3 for any project that includes a large storage gas heater or an indirect gas heater (as explained in Section 6.6). *The DHW-1 worksheet must also be completed whenever the DHW-3 form is submitted.*

Title Block

Enter **Project Title** and **Date**.

Indirect Gas Water Heaters

1. Enter the Storage tank Manufacturer and Model Number.
2. Enter the Boiler or Instantaneous Water Heater Manufacturer and Model Number.
3. Enter the Storage tank insulation R-value: The R-value integral with (internal to) the Tank; any External insulation R-value; and the Total of the two.
4. Enter the Storage tank volume in gallons.
5. Find the Boiler AFUE or Instantaneous Water Heater Recovery Efficiency in the appropriate appliance directory or database and enter on Line 5 in decimal fraction form (e.g., 0.78).
6. Enter the Adjusted Recovery Load on line 6 from DHW-1 Line 1e.
7. Using tank volume (Line 4) and Total R-Value (Line 5), determine Jacket Loss in MBtu/yr from Table 6-7E and enter on line 7.
8. Enter Pilot energy (Btu/hr) from appliance directory or database on line 8. Enter zero (0) for no pilot, or 800 if pilot exists but energy use is not listed in the appliance database.
9. Using the equation listed, calculate Basic Energy Use and enter the value on line 9. Also enter the value on DHW-1 Line 2a or DHW-2B Line 11b.

Large Storage Gas Water Heaters (>75,000 Btuh Input)

1. Enter the Water Heater Manufacturer.
2. Enter the Water Heater Model No.

3. Enter the actual Storage tank volume in gallons from the Appliance database.
4. Enter the Water Heater Thermal (Recovery) Efficiency from the appliance database and enter on Line 5 in decimal fraction form (e.g. 0.78).
5. Enter the Adjusted Recovery Load, from DHW-1 Line 1d or from DHW-2B Line 10b, on Line 6.
6. Enter Standby loss % from the appliance database on line 8. (For example, enter "3.2" for 3.2 percent.)
7. Using the equation listed, calculate Basic Energy Use and enter the value on line 9. Also, enter the value on DHW-1 Line 2a or on DHW-2b Line 11b.

DHW-5, Combined Hydronic Space and Water Heating

Complete the DHW-5 for any project that includes a combined hydronic space and water heating system (as explained in Sections 6.5 and 8.9) to calculate the AFUE. The DHW-5 is also used to calculate the adjusted AFUE (accounting for pipe losses) when a space heating boiler is also used for water heating. *The DHW-1 worksheet must also be completed whenever the DHW-5 form is submitted.*

If water heating is provided by a dedicated (separate) hydronic space heating system, complete the DHW-1 form only.

Storage Gas

1. Enter the Recovery Efficiency, Thermal Efficiency, or Annual Fuel Utilization Efficiency (AFUE) (decimal) of the water heater or boiler.
2. Enter the calculated Average Hourly Pipe Loss, from the Pipe Loss Worksheet on the bottom of the DHW-5 form.
3. Enter the Rated Input of the water heater.
4. Determine the Effective AFUE of the system, by first dividing Line 2 by Line 3, then subtracting that value from Line 1. This value is used for prescriptive compliance.

Storage Electric

1. Enter the calculated **Average Hourly Pipe Loss**, from the **Pipe Loss Worksheet** on the bottom of the DHW-5 form.
2. Enter the **Rated Input** of the water heater.
3. Enter the **Pump Watts** of the water heater and all other pumps associated with the system.
4. Calculate **Term A** from Lines 1 and 2. Multiply Line 2 by 3.413, then divide Line 1 by this value. Subtract the result from 1.
5. Calculate **Term B** from Lines 2 and 3. Multiply Line 3 by 1000, then divide Line 3 by this value, and add 1.
6. Calculate the **Effective HSPF (no fan)** by first dividing Line 4 by Line 5, then multiplying the result by 3.413. This value is used in the packages.
7. Calculate the **Effective HSPF (with fan)** by first dividing 1 by Line 6, then adding 0.005. Next divide the result into 1.017. This value is used in the packages.

Heat Pump

1. Enter the **Energy Factor** (decimal) of the water heater.
2. Enter the **Average Hourly Pipe Loss** from the **Pipe Loss Worksheet** on the bottom of the DHW-5 form.
3. Enter the **Rated Input** of the water heater.
4. Determine the **Recovery Efficiency** of the water heater. Divide 1 by Line 1, then subtract 0.1175. Divide the result into 1.
5. Enter the **Climate Zone Adjustment** value from the table on the form.
   Calculate the **Effective HSPF (no fan)** by first multiplying 3.413 by Line 3, then dividing this value into Line 2. Next subtract this value from the value resulting from dividing Line 4 by Line 5. Multiply this result by 3.413. This value is used in the packages.
7. Calculate the **Effective HSPF (with fan)** by first dividing 1 by Line 6, then adding 0.005. Next divide the result into 1.017. This value is used in the packages.

Pipe Loss Worksheet

1. Include **Description(s)** of any piping with more than 10 feet of pipe in unconditioned space between supply and distribution systems.

2. Enter **Pipe Loss Rate** for type(s) of pipe from table on the form.
3. Enter the **Pipe Length** of each pipe outside conditioned space.
4. Calculate **Total Pipe Loss** by multiplying pipe loss rate by pipe length.
   Sum all pipe losses from step 4.
6. Divide the value from step 5 by 8760 to determine the **Average Hourly Pipe Loss (kBtu/hr)**.

If the **Pipe Losses** section is not applicable (less than 10 feet of pipe in unconditioned space), enter zero for the **Average Hourly Pipe Loss**.

Table 6-6A – Standard Recovery Load and Standard Energy Use[1]

Floor Area	*Standard Recovery Load*	*Standard Energy Use*	*Floor Area*	*Standard Recovery Load*	*Standard Energy Use*
< 111	6.4	16.9	626 - 675	8.4	19.5
111 - 130	6.5	17.0	676 - 726	8.6	19.8
131 - 150	6.5	17.0	726 - 775	8.8	20.0
151 - 170	6.6	17.1	776 - 825	9.0	20.3
171 - 190	6.7	17.2	826 - 875	9.2	20.5
191 - 210	6.8	17.3	876 - 925	9.4	20.7
211 - 230	6.8	17.4	926 - 975	9.5	21.0
231 - 250	6.9	17.5	976 - 1050	9.8	21.3
251 - 270	7.0	17.6	1051 - 1150	10.1	21.7
271 - 290	7.1	17.7	1151 - 1250	10.5	22.2
291 - 310	7.1	17.8	1251 - 1350	10.9	22.7
311 - 330	7.2	17.9	1351 - 1450	11.3	23.2
331 - 350	7.3	18.0	1451 - 1550	11.6	23.6
351 - 370	7.3	18.1	1551 - 1650	12.0	24.1
371 - 390	7.4	18.2	1651 - 1750	12.4	24.6
391 - 410	7.5	18.3	1751 - 1850	12.8	25.1
411 - 430	7.6	18.4	1851 - 1950	13.2	25.6
431 - 450	7.6	18.5	1951 - 2050	13.6	26.1
451 - 470	7.7	18.6	2051 - 2150	14.0	26.6
471 - 490	7.8	18.7	2151 - 2250	14.4	27.0
491 - 525	7.9	18.8	2251 - 2350	14.8	27.5
526 - 575	8.0	19.0	2351 - 2500	15.3	28.1
576 - 625	8.2	19.3	> 2500	15.6	28.5

Table 6-6B – Standard Recovery Load and Standard Energy Use[1]

Standard Recovery Load	Standard	Point of Use	Hot Water Recovery	Parallel Piping	Recirculation Systems				
					Time/Temp	Demand	Time	Temp	No Control
< 6.3	0.0	1.1	1.1	0.9	0.3	0.1	-1.8	-0.3	-3.3
6.3 – 6.99	0.0	1.2	1.2	0.9	0.3	0.1	-1.8	-0.3	-3.4
7.0 – 7.49	0.0	1.3	1.3	1.0	0.3	0.1	-2.0	-0.4	-3.7
7.5 – 7.99	0.0	1.4	1.4	1.1	0.3	0.2	-2.2	-0.4	-4.0
8.0 – 8.49	0.0	1.5	1.5	1.1	0.3	0.2	-2.3	-0.4	-4.3
8.5 – 8.99	0.0	1.6	1.6	1.2	0.3	0.2	-2.4	-0.4	-4.5
9.0 – 9.49	0.0	1.7	1.7	1.3	0.4	0.2	-2.6	-0.5	-4.8
9.5 – 9.99	0.0	1.7	1.7	1.4	0.4	0.2	-2.7	-0.5	-5.0
10.0 - 10.99	0.0	1.8	1.8	1.4	0.4	0.2	-2.9	-0.5	-5.3
11.0 - 11.99	0.0	2.0	2.0	1.6	0.4	0.2	-3.1	-0.6	-5.8
12.0 - 12.99	0.0	2.2	2.2	1.7	0.5	0.2	-3.4	-0.6	-6.3
13.0 - 13.99	0.0	2.4	2.4	1.8	0.5	0.3	-3.7	-0.7	-6.9
14.0 - 15.99	0.0	2.6	2.6	2.0	0.6	0.3	-4.0	-0.7	-7.4
16.0 - 17.99	0.0	2.9	2.9	2.3	0.6	0.3	-4.5	-0.8	-8.4
18.0 - 19.99	0.0	3.3	3.3	2.5	0.7	0.4	-5.1	-0.9	-9.5
20.0 - 21.99	0.0	3.6	3.6	2.8	0.8	0.4	-5.7	-1.0	-10.5
22.0 - 23.99	0.0	4.0	4.0	3.1	0.9	0.4	-6.2	-1.1	-11.5
24.0 - 25.99	0.0	4.4	4.4	3.4	1.0	0.5	-6.8	-1.2	-12.6
26.0+	0.0	4.8	4.8	3.7	1.1	0.5	-7.4	-1.3	-13.7

Table 6-6C – Standard Recovery Load and Standard Energy Use[1]

					Recirculation Systems				
Standard Recovery Load	***Standard***	***Point of Use***	***Hot Water Recovery***	***Parallel Piping***	***Time/Temp***	***Demand***	***Time***	***Temp***	***No Control***
< 6.3	0.0	0.0	0.0	0.9	-3.3	-3.3	-3.3	-0.3	-3.3
6.3 - 6.99	0.0	0.0	0.0	0.9	-3.4	-3.4	-3.4	-0.3	-3.4
7.0 - 7.49	0.0	0.0	0.0	1.0	-3.7	-3.7	-3.7	-0.4	-3.7
7.5 - 7.99	0.0	0.0	0.0	1.1	-4.0	-4.0	-4.0	-0.4	-4.0
8.0 - 8.49	0.0	0.0	0.0	1.1	-4.3	-4.3	-4.3	-0.4	-4.3
8.5 - 8.99	0.0	0.0	0.0	1.2	-4.5	-4.5	-4.5	-0.4	-4.5
9.0 - 9.49	0.0	0.0	0.0	1.3	-4.8	-4.8	-4.8	-0.5	-4.8
9.5 - 9.99	0.0	0.0	0.0	1.4	-5.0	-5.0	-5.0	-0.5	-5.0
10.0 - 10.99	0.0	0.0	0.0	1.4	-5.3	-5.3	-5.3	-0.5	-5.3
11.0 - 11.99	0.0	0.0	0.0	1.6	-5.8	-5.8	-5.8	-0.6	-5.8
12.0 - 12.99	0.0	0.0	0.0	1.7	-6.3	-6.3	-6.3	-0.6	-6.3
13.0 - 13.99	0.0	0.0	0.0	1.8	-6.9	-6.9	-6.9	-0.7	-6.9
14.0 - 15.99	0.0	0.0	0.0	2.0	-7.4	-7.4	-7.4	-0.7	-7.4
16.0 - 17.99	0.0	0.0	0.0	2.3	-8.4	-8.4	-8.4	-0.8	-8.4
18.0 - 19.99	0.0	0.0	0.0	2.5	-9.5	-9.5	-9.5	-0.9	-9.5
20.0 - 21.99	0.0	0.0	0.0	2.8	-10.5	-10.5	-10.5	-1.0	-10.5
22.0 - 23.99	0.0	0.0	0.0	3.1	-11.5	-11.5	-11.5	-1.1	-11.5
24.0 - 25.99	0.0	0.0	0.0	3.4	-12.6	-12.6	-12.6	-1.2	-12.6
26.0+	0.0	0.0	0.0	3.7	-13.7	-13.7	-13.7	-1.3	-13.7

1. Hot water recovery and pipe insulation credits may only be applied to non-recirculating systems and demand recirculating systems. All other recirculating systems must have pipe insulation as explained in Section 6.6.

Table 6-7A – Basic Energy Use (BEU) - Storage Gas Heater [no interpolation]*

Adjusted Recovery Load	Energy Factor																						
	0.45	0.46	0.47	0.48	0.49	0.50	0.51	0.52	0.53	0.54	0.55	0.56	0.57	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.74	0.78	0.82
3.0	19.9	18.5	17.3	16.2	15.3	14.4	13.7	13.0	12.4	11.8	11.3	10.8	10.4	10.0	9.3	8.7	8.1	7.7	7.2	6.8	6.2	5.7	5.2
3.2	19.6	18.3	17.2	16.2	15.3	14.5	13.8	13.1	12.6	12.0	11.5	11.1	10.6	10.3	9.6	8.9	8.4	7.9	7.5	7.1	6.5	5.9	5.5
3.4	19.4	18.2	17.2	16.2	15.4	14.6	14.0	13.3	12.8	12.2	11.8	11.3	10.9	10.5	9.8	9.2	8.7	8.2	7.8	7.4	6.7	6.2	5.7
3.6	19.3	18.2	17.2	16.3	15.5	14.8	14.2	13.6	13.0	12.5	12.0	11.6	11.2	10.8	10.1	9.5	9.0	8.5	8.1	7.7	7.0	6.4	5.9
3.8	19.3	18.2	17.3	16.5	15.7	15.0	14.4	13.8	13.2	12.7	12.3	11.8	11.4	11.1	10.4	9.8	9.2	8.8	8.3	7.9	7.3	6.7	6.2
4.0	19.3	18.3	17.4	16.6	15.9	15.2	14.6	14.0	13.5	13.0	12.5	12.1	11.7	11.3	10.7	10.1	9.5	9.0	8.6	8.2	7.5	6.9	6.4
4.2	19.4	18.4	17.6	16.8	16.1	15.4	14.8	14.2	13.7	13.2	12.8	12.4	12.0	11.6	10.9	10.3	9.8	9.3	8.9	8.5	7.8	7.2	6.7
4.4	19.5	18.6	17.7	17.0	16.3	15.6	15.0	14.5	14.0	13.5	13.1	12.6	12.3	11.9	11.2	10.6	10.1	9.6	9.1	8.7	8.0	7.4	6.9
4.6	19.6	18.7	17.9	17.2	16.5	15.9	15.3	14.7	14.2	13.8	13.3	12.9	12.5	12.2	11.5	10.9	10.3	9.8	9.4	9.0	8.3	7.7	7.1
4.8	19.8	18.9	18.1	17.4	16.7	16.1	15.5	15.0	14.5	14.0	13.6	13.2	12.8	12.4	11.8	11.2	10.6	10.1	9.7	9.3	8.5	7.9	7.4
5.0	19.9	19.1	18.3	17.6	17.0	16.4	15.8	15.3	14.8	14.3	13.9	13.5	13.1	12.7	12.0	11.4	10.9	10.4	9.9	9.5	8.8	8.1	7.6
5.2	20.1	19.3	18.5	17.8	17.2	16.6	16.0	15.5	15.0	14.6	14.1	13.7	13.3	13.0	12.3	11.7	11.1	10.6	10.2	9.8	9.0	8.4	7.8
5.4	20.3	19.5	18.8	18.1	17.4	16.9	16.3	15.8	15.3	14.8	14.4	14.0	13.6	13.2	12.6	12.0	11.4	10.9	10.4	10.0	9.3	8.6	8.1
5.6	20.5	19.7	19.0	18.3	17.7	17.1	16.6	16.0	15.6	15.1	14.7	14.3	13.9	13.5	12.8	12.2	11.7	11.2	10.7	10.3	9.5	8.9	8.3
5.8	20.7	19.9	19.2	18.6	17.9	17.4	16.8	16.3	15.8	15.4	14.9	14.5	14.1	13.8	13.1	12.5	11.9	11.4	11.0	10.5	9.8	9.1	8.5
6.0	20.9	20.2	19.5	18.8	18.2	17.6	17.1	16.6	16.1	15.6	15.2	14.8	14.4	14.0	13.4	12.8	12.2	11.7	11.2	10.8	10.0	9.3	8.7
6.2	21.2	20.4	19.7	19.1	18.4	17.9	17.3	16.8	16.3	15.9	15.5	15.1	14.7	14.3	13.6	13.0	12.5	11.9	11.5	11.0	10.2	9.6	9.0
6.4	21.4	20.6	20.0	19.3	18.7	18.1	17.6	17.1	16.6	16.2	15.7	15.3	14.9	14.6	13.9	13.3	12.7	12.2	11.7	11.3	10.5	9.8	9.2
6.6	21.6	20.9	20.2	19.6	19.0	18.4	17.9	17.4	16.9	16.4	16.0	15.6	15.2	14.8	14.2	13.5	13.0	12.4	12.0	11.5	10.7	10.0	9.4
6.8	21.9	21.1	20.5	19.8	19.2	18.7	18.1	17.6	17.1	16.7	16.3	15.9	15.5	15.1	14.4	13.8	13.2	12.7	12.2	11.8	10.9	10.2	9.6
7.0	22.1	21.4	20.7	20.1	19.5	18.9	18.4	17.9	17.4	17.0	16.5	16.1	15.7	15.4	14.7	14.1	13.5	12.9	12.5	12.0	11.2	10.5	9.8
7.2	22.3	21.6	21.0	20.3	19.7	19.2	18.6	18.1	17.7	17.2	16.8	16.4	16.0	15.6	14.9	14.3	13.7	13.2	12.7	12.2	11.4	10.7	10.1
7.4	22.6	21.9	21.2	20.6	20.0	19.4	18.9	18.4	17.9	17.5	17.1	16.7	16.3	15.9	15.2	14.6	14.0	13.4	12.9	12.5	11.6	10.9	10.3
7.6	22.8	22.1	21.5	20.8	20.3	19.7	19.2	18.7	18.2	17.8	17.3	16.9	16.5	16.2	15.5	14.8	14.2	13.7	13.2	12.7	11.9	11.1	10.5
7.8	23.1	22.4	21.7	21.1	20.5	20.0	19.4	18.9	18.5	18.0	17.6	17.2	16.8	16.4	15.7	15.1	14.5	13.9	13.4	13.0	12.1	11.4	10.7
8.0	23.3	22.6	22.0	21.4	20.8	20.2	19.7	19.2	18.7	18.3	17.8	17.4	17.0	16.7	16.0	15.3	14.7	14.2	13.7	13.2	12.3	11.6	10.9
8.2	23.6	22.9	22.2	21.6	21.0	20.5	20.0	19.5	19.0	18.5	18.1	17.7	17.3	16.9	16.2	15.6	15.0	14.4	13.9	13.4	12.6	11.8	11.1
8.4	23.8	23.1	22.5	21.9	21.3	20.7	20.2	19.7	19.3	18.8	18.4	18.0	17.6	17.2	16.5	15.8	15.2	14.7	14.2	13.7	12.8	12.0	11.3
8.6	24.1	23.4	22.8	22.1	21.6	21.0	20.5	20.0	19.5	19.1	18.6	18.2	17.8	17.4	16.7	16.1	15.5	14.9	14.4	13.9	13.0	12.2	11.6
8.8	24.3	23.7	23.0	22.4	21.8	21.3	20.7	20.2	19.8	19.3	18.9	18.5	18.1	17.7	17.0	16.3	15.7	15.2	14.6	14.1	13.2	12.5	11.8
9.0	24.6	23.9	23.3	22.7	22.1	21.5	21.0	20.5	20.0	19.6	19.1	18.7	18.3	18.0	17.2	16.6	16.0	15.4	14.9	14.4	13.5	12.7	12.0
9.2	24.8	24.2	23.5	22.9	22.3	21.8	21.3	20.8	20.3	19.8	19.4	19.0	18.6	18.2	17.5	16.8	16.2	15.6	15.1	14.6	13.7	12.9	12.2
9.4	25.1	24.4	23.8	23.2	22.6	22.0	21.5	21.0	20.5	20.1	19.7	19.2	18.8	18.5	17.7	17.1	16.4	15.9	15.3	14.8	13.9	13.1	12.4
9.6	25.4	24.7	24.0	23.4	22.9	22.3	21.8	21.3	20.8	20.3	19.9	19.5	19.1	18.7	18.0	17.3	16.7	16.1	15.6	15.1	14.1	13.3	12.6
9.8	25.6	24.9	24.3	23.7	23.1	22.6	22.0	21.5	21.1	20.6	20.2	19.7	19.3	19.0	18.2	17.6	16.9	16.3	15.8	15.3	14.4	13.5	12.8
10.0	25.9	25.2	24.6	23.9	23.4	22.8	22.3	21.8	21.3	20.9	20.4	20.0	19.6	19.2	18.5	17.8	17.2	16.6	16.0	15.5	14.6	13.8	13.0
10.5	26.5	25.8	25.2	24.6	24.0	23.5	22.9	22.4	22.0	21.5	21.0	20.6	20.2	19.8	19.1	18.4	17.8	17.2	16.6	16.1	15.1	14.3	13.5
11.0	27.1	26.5	25.8	25.2	24.7	24.1	23.6	23.1	22.6	22.1	21.7	21.2	20.8	20.4	19.7	19.0	18.4	17.7	17.2	16.6	15.7	14.8	14.0
11.5	27.8	27.1	26.5	25.9	25.3	24.7	24.2	23.7	23.2	22.7	22.3	21.9	21.5	21.1	20.3	19.6	18.9	18.3	17.7	17.2	16.2	15.3	14.5
12.0	28.4	27.7	27.1	26.5	25.9	25.4	24.8	24.3	23.8	23.4	22.9	22.5	22.1	21.7	20.9	20.2	19.5	18.9	18.3	17.8	16.8	15.9	15.1
12.5	29.0	28.4	27.7	27.1	26.6	26.0	25.5	25.0	24.5	24.0	23.5	23.1	22.7	22.3	21.5	20.8	20.1	19.5	18.9	18.3	17.3	16.4	15.6
13.0	29.7	29.0	28.4	27.8	27.2	26.6	26.1	25.6	25.1	24.6	24.1	23.7	23.3	22.9	22.1	21.3	20.7	20.0	19.4	18.9	17.8	16.9	16.0
13.5	30.3	29.6	29.0	28.4	27.8	27.2	26.7	26.2	25.7	25.2	24.7	24.3	23.9	23.5	22.7	21.9	21.2	20.6	20.0	19.4	18.3	17.4	16.5
14.0	30.9	30.3	29.6	29.0	28.4	27.9	27.3	26.8	26.3	25.8	25.3	24.9	24.5	24.0	23.2	22.5	21.8	21.1	20.5	19.9	18.9	17.9	17.0
14.5	31.6	30.9	30.3	29.6	29.0	28.5	27.9	27.4	26.9	26.4	25.9	25.5	25.1	24.6	23.8	23.1	22.4	21.7	21.1	20.5	19.4	18.4	17.5
15.0	32.2	31.5	30.9	30.3	29.7	29.1	28.5	28.0	27.5	27.0	26.5	26.1	25.6	25.2	24.4	23.6	22.9	22.2	21.6	21.0	19.9	18.9	18.0
15.5	32.8	32.1	31.5	30.9	30.3	29.7	29.1	28.6	28.1	27.6	27.1	26.7	26.2	25.8	25.0	24.2	23.5	22.8	22.2	21.5	20.4	19.4	18.5
16.0	33.4	32.7	32.1	31.5	30.9	30.3	29.8	29.2	28.7	28.2	27.7	27.3	26.8	26.4	25.5	24.8	24.0	23.3	22.7	22.1	20.9	19.9	19.0
16.5	34.0	33.4	32.7	32.1	31.5	30.9	30.3	29.8	29.3	28.8	28.3	27.8	27.4	26.9	26.1	25.3	24.6	23.9	23.2	22.6	21.4	20.4	19.5
17.0	34.7	34.0	33.3	32.7	32.1	31.5	30.9	30.4	29.9	29.4	28.9	28.4	28.0	27.5	26.7	25.9	25.1	24.4	23.8	23.1	22.0	20.9	19.9
17.5	35.3	34.6	33.9	33.3	32.7	32.1	31.5	31.0	30.5	30.0	29.5	29.0	28.5	28.1	27.2	26.4	25.7	25.0	24.3	23.6	22.5	21.4	20.4
18.0	35.9	35.2	34.5	33.9	33.3	32.7	32.1	31.6	31.1	30.5	30.0	29.6	29.1	28.6	27.8	27.0	26.2	25.5	24.8	24.2	23.0	21.9	20.9
18.5	36.5	35.8	35.1	34.5	33.9	33.3	32.7	32.2	31.6	31.1	30.6	30.1	29.7	29.2	28.3	27.5	26.8	26.0	25.3	24.7	23.5	22.4	21.4
19.0	37.1	36.4	35.7	35.1	34.5	33.9	33.3	32.8	32.2	31.7	31.2	30.7	30.2	29.8	28.9	28.1	27.3	26.5	25.8	25.2	24.0	22.8	21.8
19.5	37.7	37.0	36.3	35.7	35.1	34.5	33.9	33.3	32.8	32.3	31.8	31.3	30.8	30.3	29.4	28.6	27.8	27.1	26.4	25.7	24.5	23.3	22.3
20.0	38.3	37.6	36.9	36.3	35.7	35.1	34.5	33.9	33.4	32.8	32.3	31.8	31.3	30.9	30.0	29.1	28.4	27.6	26.9	26.2	24.9	23.8	22.8
21.0	39.5	38.8	38.1	37.4	36.8	36.2	35.6	35.1	34.5	34.0	33.4	32.9	32.5	32.0	31.1	30.2	29.4	28.6	27.9	27.2	25.9	24.8	23.7
22.0	40.7	40.0	39.3	38.6	38.0	37.4	36.8	36.2	35.6	35.1	34.6	34.1	33.6	33.1	32.2	31.3	30.5	29.7	28.9	28.2	26.9	25.7	24.6

* The Basic Energy Use obtained from this table is to be used in Equation 6-1.

Table 6-7B– Basic Energy Use (BEU) - Storage Electric Heater [no interpolation]*

Adj Recovery Load	Energy Factor																						
	0.77	0.78	0.79	0.80	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99
3.0	22.4	21.1	20.0	19.0	18.1	17.2	16.5	15.8	15.2	14.6	14.0	13.5	13.0	12.6	12.2	11.8	11.5	11.1	10.8	10.5	10.2	9.9	9.7
3.2	23.0	21.8	20.7	19.7	18.8	18.0	17.2	16.5	15.9	15.3	14.7	14.2	13.8	13.3	12.9	12.5	12.1	11.8	11.5	11.1	10.8	10.6	10.3
3.4	23.6	22.4	21.3	20.4	19.5	18.7	17.9	17.2	16.6	16.0	15.4	14.9	14.4	14.0	13.6	13.2	12.8	12.4	12.1	11.8	11.5	11.2	10.9
3.6	24.2	23.1	22.0	21.1	20.2	19.4	18.6	17.9	17.3	16.7	16.1	15.6	15.1	14.7	14.2	13.8	13.5	13.1	12.7	12.4	12.1	11.8	11.5
3.8	24.8	23.7	22.7	21.7	20.9	20.1	19.3	18.6	18.0	17.4	16.8	16.3	15.8	15.4	14.9	14.5	14.1	13.7	13.4	13.1	12.7	12.4	12.1
4.0	25.5	24.4	23.3	22.4	21.6	20.8	20.0	19.3	18.7	18.1	17.5	17.0	16.5	16.0	15.6	15.2	14.8	14.4	14.0	13.7	13.4	13.1	12.8
4.2	26.1	25.0	24.0	23.1	22.2	21.4	20.7	20.0	19.4	18.8	18.2	17.7	17.2	16.7	16.3	15.8	15.4	15.0	14.7	14.3	14.0	13.7	13.4
4.4	26.7	25.6	24.7	23.8	22.9	22.1	21.4	20.7	20.1	19.5	18.9	18.4	17.8	17.4	16.9	16.5	16.1	15.7	15.3	15.0	14.6	14.3	14.0
4.6	27.3	26.3	25.3	24.4	23.6	22.8	22.1	21.4	20.7	20.1	19.6	19.0	18.5	18.0	17.6	17.1	16.7	16.3	15.9	15.6	15.2	14.9	14.6
4.8	28.0	26.9	26.0	25.1	24.3	23.5	22.7	22.1	21.4	20.8	20.2	19.7	19.2	18.7	18.2	17.8	17.4	17.0	16.6	16.2	15.9	15.5	15.2
5.0	28.6	27.6	26.6	25.7	24.9	24.1	23.4	22.7	22.1	21.5	20.9	20.4	19.8	19.3	18.9	18.4	18.0	17.6	17.2	16.8	16.5	16.1	15.8
5.2	29.2	28.2	27.3	26.4	25.6	24.8	24.1	23.4	22.7	22.1	21.6	21.0	20.5	20.0	19.5	19.1	18.6	18.2	17.8	17.5	17.1	16.7	16.4
5.4	29.8	28.8	27.9	27.0	26.2	25.5	24.7	24.1	23.4	22.8	22.2	21.7	21.1	20.6	20.2	19.7	19.3	18.9	18.5	18.1	17.7	17.4	17.0
5.6	30.4	29.5	28.5	27.7	26.9	26.1	25.4	24.7	24.1	23.5	22.9	22.3	21.8	21.3	20.8	20.3	19.9	19.5	19.1	18.7	18.3	18.0	17.6
5.8	31.0	30.1	29.2	28.3	27.5	26.8	26.0	25.4	24.7	24.1	23.5	23.0	22.4	21.9	21.4	21.0	20.5	20.1	19.7	19.3	18.9	18.6	18.2
6.0	31.6	30.7	29.8	29.0	28.2	27.4	26.7	26.0	25.4	24.7	24.2	23.6	23.1	22.6	22.1	21.6	21.2	20.7	20.3	19.9	19.5	19.2	18.8
6.2	32.3	31.3	30.4	29.6	28.8	28.0	27.3	26.7	26.0	25.4	24.8	24.2	23.7	23.2	22.7	22.2	21.8	21.4	20.9	20.5	20.2	19.8	19.4
6.4	32.9	31.9	31.1	30.2	29.4	28.7	28.0	27.3	26.6	26.0	25.4	24.9	24.3	23.8	23.3	22.9	22.4	22.0	21.6	21.2	20.8	20.4	20.0
6.6	33.5	32.5	31.7	30.8	30.1	29.3	28.6	27.9	27.3	26.7	26.1	25.5	25.0	24.5	24.0	23.5	23.0	22.6	22.2	21.8	21.4	21.0	20.6
6.8	34.1	33.2	32.3	31.5	30.7	29.9	29.2	28.6	27.9	27.3	26.7	26.2	25.6	25.1	24.6	24.1	23.7	23.2	22.8	22.4	22.0	21.6	21.2
7.0	34.7	33.8	32.9	32.1	31.3	30.6	29.9	29.2	28.6	27.9	27.3	26.8	26.2	25.7	25.2	24.7	24.3	23.8	23.4	23.0	22.6	22.2	21.8
7.2	35.3	34.4	33.5	32.7	31.9	31.2	30.5	29.8	29.2	28.6	28.0	27.4	26.9	26.3	25.8	25.4	24.9	24.4	24.0	23.6	23.2	22.8	22.4
7.4	35.9	35.0	34.1	33.3	32.6	31.8	31.1	30.5	29.8	29.2	28.6	28.0	27.5	27.0	26.5	26.0	25.5	25.1	24.6	24.2	23.8	23.4	23.0
7.6	36.5	35.6	34.7	33.9	33.2	32.4	31.7	31.1	30.4	29.8	29.2	28.7	28.1	27.6	27.1	26.6	26.1	25.7	25.2	24.8	24.4	24.0	23.6
7.8	37.0	36.2	35.3	34.5	33.8	33.1	32.4	31.7	31.1	30.4	29.8	29.3	28.7	28.2	27.7	27.2	26.7	26.3	25.8	25.4	25.0	24.6	24.2
8.0	37.6	36.8	35.9	35.2	34.4	33.7	33.0	32.3	31.7	31.1	30.5	29.9	29.4	28.8	28.3	27.8	27.3	26.9	26.4	26.0	25.6	25.2	24.8
8.2	38.2	37.4	36.5	35.8	35.0	34.3	33.6	32.9	32.3	31.7	31.1	30.5	30.0	29.4	28.9	28.4	28.0	27.5	27.0	26.6	26.2	25.8	25.4
8.4	38.8	37.9	37.1	36.4	35.6	34.9	34.2	33.5	32.9	32.3	31.7	31.1	30.6	30.0	29.5	29.0	28.6	28.1	27.7	27.2	26.8	26.4	26.0
8.6	39.4	38.5	37.7	37.0	36.2	35.5	34.8	34.2	33.5	32.9	32.3	31.7	31.2	30.7	30.1	29.7	29.2	28.7	28.3	27.8	27.4	27.0	26.6
8.8	40.0	39.1	38.3	37.6	36.8	36.1	35.4	34.8	34.1	33.5	32.9	32.4	31.8	31.3	30.8	30.3	29.8	29.3	28.9	28.4	28.0	27.6	27.2
9.0	40.5	39.7	38.9	38.1	37.4	36.7	36.0	35.4	34.7	34.1	33.5	33.0	32.4	31.9	31.4	30.9	30.4	29.9	29.5	29.0	28.6	28.2	27.8
9.2	41.1	40.3	39.5	38.7	38.0	37.3	36.6	36.0	35.3	34.7	34.1	33.6	33.0	32.5	32.0	31.5	31.0	30.5	30.1	29.6	29.2	28.8	28.4
9.4	41.7	40.9	40.1	39.3	38.6	37.9	37.2	36.6	35.9	35.3	34.7	34.2	33.6	33.1	32.6	32.1	31.6	31.1	30.7	30.2	29.8	29.4	29.0
9.6	42.3	41.4	40.7	39.9	39.2	38.5	37.8	37.2	36.5	35.9	35.3	34.8	34.2	33.7	33.2	32.7	32.2	31.7	31.3	30.8	30.4	30.0	29.5
9.8	42.8	42.0	41.2	40.5	39.8	39.1	38.4	37.8	37.1	36.5	35.9	35.4	34.8	34.3	33.8	33.3	32.8	32.3	31.9	31.4	31.0	30.5	30.1
10.0	43.4	42.6	41.8	41.1	40.4	39.7	39.0	38.4	37.7	37.1	36.5	36.0	35.4	34.9	34.4	33.9	33.4	32.9	32.4	32.0	31.6	31.1	30.7
10.5	44.8	44.0	43.3	42.5	41.8	41.1	40.5	39.8	39.2	38.6	38.0	37.5	36.9	36.4	35.9	35.4	34.9	34.4	33.9	33.5	33.0	32.6	32.2
11.0	46.2	45.4	44.7	44.0	43.3	42.6	41.9	41.3	40.7	40.1	39.5	39.0	38.4	37.9	37.4	36.8	36.4	35.9	35.4	35.0	34.5	34.1	33.7
11.5	47.6	46.8	46.1	45.4	44.7	44.0	43.4	42.8	42.2	41.6	41.0	40.4	39.9	39.3	38.8	38.3	37.8	37.4	36.9	36.4	36.0	35.6	35.1
12.0	49.0	48.2	47.5	46.8	46.1	45.5	44.8	44.2	43.6	43.0	42.5	41.9	41.3	40.8	40.3	39.8	39.3	38.8	38.4	37.9	37.5	37.0	36.6
12.5	50.3	49.6	48.9	48.2	47.6	46.9	46.3	45.7	45.1	44.5	43.9	43.4	42.8	42.3	41.8	41.3	40.8	40.3	39.8	39.4	38.9	38.5	38.1
13.0	51.7	51.0	50.3	49.6	49.0	48.3	47.7	47.1	46.5	45.9	45.4	44.8	44.3	43.7	43.2	42.7	42.2	41.8	41.3	40.8	40.4	40.0	39.5
13.5	53.1	52.4	51.7	51.0	50.4	49.7	49.1	48.5	47.9	47.3	46.8	46.2	45.7	45.2	44.7	44.2	43.7	43.2	42.8	42.3	41.8	41.4	41.0
14.0	54.4	53.7	53.0	52.4	51.7	51.1	50.5	49.9	49.3	48.8	48.2	47.7	47.2	46.6	46.1	45.6	45.1	44.7	44.2	43.8	43.3	42.9	42.4
14.5	55.7	55.1	54.4	53.8	53.1	52.5	51.9	51.3	50.8	50.2	49.6	49.1	48.6	48.1	47.6	47.1	46.6	46.1	45.7	45.2	44.8	44.3	43.9
15.0	57.1	56.4	55.7	55.1	54.5	53.9	53.3	52.7	52.2	51.6	51.1	50.5	50.0	49.5	49.0	48.5	48.0	47.6	47.1	46.7	46.2	45.8	45.3
15.5	58.4	57.7	57.1	56.5	55.9	55.3	54.7	54.1	53.6	53.0	52.5	52.0	51.4	50.9	50.4	50.0	49.5	49.0	48.5	48.1	47.7	47.2	46.8
16.0	59.7	59.1	58.4	57.8	57.2	56.6	56.1	55.5	54.9	54.4	53.9	53.4	52.9	52.4	51.9	51.4	50.9	50.4	50.0	49.5	49.1	48.7	48.2
16.5	61.0	60.4	59.8	59.2	58.6	58.0	57.4	56.9	56.3	55.8	55.3	54.8	54.3	53.8	53.3	52.8	52.3	51.9	51.4	51.0	50.5	50.1	49.7
17.0	62.3	61.7	61.1	60.5	59.9	59.4	58.8	58.3	57.7	57.2	56.7	56.2	55.7	55.2	54.7	54.2	53.8	53.3	52.9	52.4	52.0	51.6	51.1
17.5	63.6	63.0	62.4	61.8	61.3	60.7	60.2	59.6	59.1	58.6	58.1	57.6	57.1	56.6	56.1	55.6	55.2	54.7	54.3	53.9	53.4	53.0	52.6
18.0	64.9	64.3	63.7	63.1	62.6	62.0	61.5	61.0	60.5	59.9	59.4	59.0	58.5	58.0	57.5	57.1	56.6	56.2	55.7	55.3	54.9	54.4	54.0
18.5	66.1	65.6	65.0	64.5	63.9	63.4	62.8	62.3	61.8	61.3	60.8	60.3	59.9	59.4	58.9	58.5	58.0	57.6	57.1	56.7	56.3	55.9	55.5
19.0	67.4	66.9	66.3	65.8	65.2	64.7	64.2	63.7	63.2	62.7	62.2	61.7	61.2	60.8	60.3	59.9	59.4	59.0	58.6	58.1	57.7	57.3	56.9
19.5	68.7	68.1	67.6	67.1	66.5	66.0	65.5	65.0	64.5	64.0	63.6	63.1	62.6	62.2	61.7	61.3	60.8	60.4	60.0	59.6	59.2	58.7	58.3
20.0	70.0	69.4	68.9	68.4	67.9	67.3	66.8	66.4	65.9	65.4	64.9	64.5	64.0	63.6	63.1	62.7	62.3	61.8	61.4	61.0	60.6	60.2	59.8
21.0	72.5	71.9	71.4	70.9	70.5	70.0	69.5	69.0	68.6	68.1	67.6	67.2	66.8	66.3	65.9	65.5	65.1	64.6	64.2	63.8	63.4	63.0	62.7
22.0	74.9	74.5	74.0	73.5	73.0	72.6	72.1	71.7	71.2	70.8	70.3	69.9	69.5	69.1	68.7	68.2	67.8	67.4	67.1	66.7	66.3	65.9	65.5

* The Basic Energy Use obtained from this table is to be used in Equation 6-1.

Table 6-7C– Basic Energy Use (BEU) - Storage Heat Pump Heater [no interpolation]*

Adjusted Recovery Load	Energy Factor																				
	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8
6.0	14.1	13.5	13.0	12.6	12.1	11.7	11.3	11.0	10.6	10.3	10.0	9.7	9.5	9.2	9.0	8.7	8.5	8.3	8.1	7.9	7.8
6.2	14.4	13.8	13.3	12.8	12.3	11.9	11.5	11.1	10.8	10.5	10.2	9.9	9.6	9.3	9.1	8.9	8.7	8.4	8.2	8.0	7.9
6.4	14.7	14.1	13.5	13.0	12.5	12.1	11.7	11.3	11.0	10.6	10.3	10.0	9.7	9.5	9.2	9.0	8.8	8.6	8.3	8.2	8.0
6.6	14.9	14.3	13.8	13.2	12.8	12.3	11.9	11.5	11.1	10.8	10.5	10.2	9.9	9.6	9.4	9.1	8.9	8.7	8.5	8.3	8.1
6.8	15.2	14.6	14.0	13.5	13.0	12.5	12.1	11.7	11.3	11.0	10.6	10.3	10.0	9.8	9.5	9.3	9.0	8.8	8.6	8.4	8.2
7.0	15.5	14.8	14.2	13.7	13.2	12.7	12.3	11.9	11.5	11.1	10.8	10.5	10.2	9.9	9.6	9.4	9.1	8.9	8.7	8.5	8.3
7.2	15.8	15.1	14.5	13.9	13.4	12.9	12.5	12.1	11.7	11.3	11.0	10.6	10.3	10.0	9.8	9.5	9.3	9.0	8.8	8.6	8.4
7.4	16.0	15.4	14.7	14.2	13.6	13.1	12.7	12.2	11.8	11.5	11.1	10.8	10.5	10.2	9.9	9.6	9.4	9.1	8.9	8.7	8.5
7.6	16.3	15.6	15.0	14.4	13.8	13.3	12.9	12.4	12.0	11.6	11.3	10.9	10.6	10.3	10.0	9.8	9.5	9.3	9.0	8.8	8.6
7.8	16.6	15.9	15.2	14.6	14.0	13.5	13.0	12.6	12.2	11.8	11.4	11.1	10.8	10.5	10.2	9.9	9.6	9.4	9.2	8.9	8.7
8.0	16.8	16.1	15.4	14.8	14.3	13.7	13.2	12.8	12.4	12.0	11.6	11.2	10.9	10.6	10.3	10.0	9.8	9.5	9.3	9.0	8.8
8.2	17.1	16.4	15.7	15.0	14.5	13.9	13.4	13.0	12.5	12.1	11.7	11.4	11.0	10.7	10.4	10.1	9.9	9.6	9.4	9.2	8.9
8.4	17.4	16.6	15.9	15.3	14.7	14.1	13.6	13.1	12.7	12.3	11.9	11.5	11.2	10.9	10.6	10.3	10.0	9.7	9.5	9.3	9.0
8.6	17.7	16.9	16.1	15.5	14.9	14.3	13.8	13.3	12.9	12.4	12.0	11.7	11.3	11.0	10.7	10.4	10.1	9.9	9.6	9.4	9.1
8.8	17.9	17.1	16.4	15.7	15.1	14.5	14.0	13.5	13.0	12.6	12.2	11.8	11.5	11.1	10.8	10.5	10.2	10.0	9.7	9.5	9.3
9.0	18.2	17.4	16.6	15.9	15.3	14.7	14.2	13.7	13.2	12.8	12.4	12.0	11.6	11.3	11.0	10.7	10.4	10.1	9.8	9.6	9.4
9.2	18.4	17.6	16.8	16.1	15.5	14.9	14.4	13.9	13.4	12.9	12.5	12.1	11.8	11.4	11.1	10.8	10.5	10.2	10.0	9.7	9.5
9.4	18.7	17.9	17.1	16.4	15.7	15.1	14.5	14.0	13.5	13.1	12.7	12.3	11.9	11.5	11.3	10.9	10.6	10.3	10.1	9.8	9.6
9.6	19.0	18.1	17.3	16.6	15.9	15.3	14.7	14.2	13.7	13.3	12.8	12.4	12.0	11.7	11.4	11.0	10.7	10.5	10.2	9.9	9.7
9.8	19.2	18.3	17.5	16.8	16.1	15.5	14.9	14.4	13.9	13.4	13.0	12.6	12.2	11.8	11.5	11.2	10.9	10.6	10.3	10.0	9.8
10.0	19.5	18.6	17.8	17.0	16.3	15.7	15.1	14.6	14.0	13.6	13.1	12.7	12.3	12.0	11.7	11.3	11.0	10.7	10.4	10.1	9.9
10.5	20.1	19.2	18.3	17.6	16.8	16.2	15.6	15.0	14.5	14.0	13.5	13.1	12.7	12.3	11.9	11.6	11.3	11.0	10.7	10.4	10.2
11.0	20.8	19.8	18.9	18.1	17.3	16.7	16.0	15.4	14.9	14.4	13.9	13.4	13.0	12.6	12.3	11.9	11.6	11.3	11.0	10.7	10.4
11.5	21.4	20.4	19.5	18.6	17.8	17.1	16.5	15.9	15.3	14.8	14.3	13.8	13.4	13.0	12.6	12.2	11.9	11.6	11.3	11.0	10.7
12.0	22.1	21.0	20.0	19.1	18.3	17.6	16.9	16.3	15.7	15.1	14.6	14.2	13.7	13.3	12.9	12.5	12.2	11.9	11.5	11.2	11.0
12.5	22.7	21.6	20.6	19.7	18.8	18.1	17.4	16.7	16.1	15.5	15.0	14.5	14.1	13.6	13.2	12.8	12.5	12.1	11.8	11.5	11.2
13.0	23.3	22.2	21.1	20.2	19.3	18.5	17.8	17.1	16.5	15.9	15.4	14.9	14.4	14.0	13.5	13.1	12.8	12.4	12.1	11.8	11.5
13.5	23.9	22.7	21.7	20.7	19.8	19.0	18.2	17.6	16.9	16.3	15.8	15.2	14.7	14.3	13.9	13.5	13.1	12.7	12.4	12.0	11.7
14.0	24.5	23.3	22.2	21.2	20.3	19.5	18.7	18.0	17.3	16.7	16.1	15.6	15.1	14.6	14.2	13.8	13.4	13.0	12.6	12.3	12.0
14.5	25.2	23.9	22.8	21.7	20.8	19.9	19.1	18.4	17.7	17.1	16.5	15.9	15.4	14.9	14.5	14.1	13.7	13.3	12.9	12.6	12.3
15.0	25.8	24.5	23.3	22.2	21.3	20.4	19.6	18.8	18.1	17.4	16.8	16.3	15.8	15.3	14.8	14.4	13.9	13.6	13.2	12.8	12.5
15.5	26.4	25.0	23.8	22.7	21.7	20.8	20.0	19.2	18.5	17.8	17.2	16.6	16.1	15.6	15.1	14.7	14.2	13.8	13.5	13.1	12.8
16.0	27.0	25.6	24.4	23.2	22.2	21.3	20.4	19.6	18.9	18.2	17.6	17.0	16.4	15.9	15.4	15.0	14.5	14.1	13.7	13.4	13.0
16.5	27.6	26.2	24.9	23.7	22.7	21.7	20.8	20.0	19.3	18.6	17.9	17.3	16.7	16.2	15.7	15.2	14.8	14.4	14.0	13.6	13.3
17.0	28.2	26.7	25.4	24.2	23.2	22.2	21.3	20.4	19.7	18.9	18.3	17.7	17.1	16.5	16.0	15.5	15.1	14.7	14.3	13.9	13.5
17.5	28.8	27.3	25.9	24.7	23.6	22.6	21.7	20.8	20.0	19.3	18.6	18.0	17.4	16.8	16.3	15.8	15.4	14.9	14.5	14.1	13.8
18.0	29.4	27.8	26.5	25.2	24.1	23.1	22.1	21.2	20.4	19.7	19.0	18.3	17.7	17.2	16.6	16.1	15.7	15.2	14.8	14.4	14.0
18.5	29.9	28.4	27.0	25.7	24.5	23.5	22.5	21.6	20.8	20.0	19.3	18.7	18.0	17.5	16.9	16.4	15.9	15.5	15.1	14.7	14.3
19.0	30.5	28.9	27.5	26.2	25.0	23.9	23.3	22.0	21.2	20.4	19.7	19.0	18.4	17.8	17.2	16.7	16.2	15.8	15.3	14.9	14.5
19.5	31.1	29.5	28.0	26.7	25.5	24.4	23.3	22.4	21.6	20.8	20.0	19.3	18.7	18.1	17.5	17.0	16.5	16.0	15.6	15.2	14.8
20.0	31.7	30.0	28.5	27.2	25.9	24.8	23.8	22.8	21.9	21.1	20.4	19.7	19.0	18.4	17.8	17.3	16.8	16.3	15.8	15.4	15.0
21.0	32.8	31.1	29.5	28.1	26.8	25.7	24.6	23.6	22.7	21.8	21.1	20.3	19.6	19.0	18.4	17.8	17.3	16.8	16.4	15.9	15.5
22.0	34.0	32.2	30.5	29.1	27.7	26.5	25.4	24.4	23.4	22.5	21.7	21.0	20.3	19.6	19.0	18.4	17.9	17.4	16.9	16.4	16.0

* The Basic Energy Use obtained from this table is to be used in Equation 6-1.

Table 6-7D– Basic Energy Use (BEU) - Instantaneous Gas or Electric Heaters [no interpolation]

	Pilot Energy (Btu/Hour)												
Recovery Energy	200	250	300	350	400	450	500	550	600	650	700	750	800
3.0	4.8	5.2	5.6	6.1	6.5	6.9	7.4	7.8	8.3	8.7	9.1	9.6	10.0
3.2	5.0	5.4	5.8	6.3	6.7	7.1	7.6	8.0	8.5	8.9	9.3	9.8	10.2
3.4	5.2	5.6	6.0	6.5	6.9	7.3	7.8	8.2	8.7	9.1	9.5	10.0	10.4
3.6	5.4	5.8	6.2	6.7	7.1	7.5	8.0	8.4	8.9	9.3	9.7	10.2	10.6
3.8	5.6	6.0	6.4	6.9	7.3	7.7	8.2	8.6	9.1	9.5	9.9	10.4	10.8
4.0	5.8	6.2	6.6	7.1	7.5	7.9	8.4	8.8	9.3	9.7	10.1	10.6	11.0
4.2	6.0	6.4	6.8	7.3	7.7	8.1	8.6	9.0	9.5	9.9	10.3	10.8	11.2
4.4	6.2	6.6	7.0	7.5	7.9	8.3	8.8	9.2	9.7	10.1	10.5	11.0	11.4
4.6	6.4	6.8	7.2	7.7	8.1	8.5	9.0	9.4	9.9	10.3	10.7	11.2	11.6
4.8	6.6	7.0	7.4	7.9	8.3	8.7	9.2	9.6	10.1	10.5	10.9	11.4	11.8
5.0	6.8	7.2	7.6	8.1	8.5	8.9	9.4	9.8	10.3	10.7	11.1	11.6	12.0
5.2	7.0	7.4	7.8	8.3	8.7	9.1	9.6	10.0	10.5	10.9	11.3	11.8	12.2
5.4	7.2	7.6	8.0	8.5	8.9	9.3	9.8	10.2	10.7	11.1	11.5	12.0	12.4
5.6	7.4	7.8	8.2	8.7	9.1	9.5	10.0	10.4	10.9	11.3	11.7	12.2	12.6
5.8	7.6	8.0	8.4	8.9	9.3	9.7	10.2	10.6	11.1	11.5	11.9	12.4	12.8
6.0	7.8	8.2	8.6	9.1	9.5	9.9	10.4	10.8	11.3	11.7	12.1	12.6	13.0
6.2	8.0	8.4	8.8	9.3	9.7	10.1	10.6	11.0	11.5	11.9	12.3	12.8	13.2
6.4	8.2	8.6	9.0	9.5	9.9	10.3	10.8	11.2	11.7	12.1	12.5	13.0	13.4
6.6	8.4	8.8	9.2	9.7	10.1	10.5	11.0	11.4	11.9	12.3	12.7	13.2	13.6
6.8	8.6	9.0	9.4	9.9	10.3	10.7	11.2	11.6	12.1	12.5	12.9	13.4	13.8
7.0	8.8	9.2	9.6	10.1	10.5	10.9	11.4	11.8	12.3	12.7	13.1	13.6	14.0
7.2	9.0	9.4	9.8	10.3	10.7	11.1	11.6	12.0	12.5	12.9	13.3	13.8	14.2
7.4	9.2	9.6	10.0	10.5	10.9	11.3	11.8	12.2	12.7	13.1	13.5	14.0	14.4
7.6	9.4	9.8	10.2	10.7	11.1	11.5	12.0	12.4	12.9	13.3	13.7	14.2	14.6
7.8	9.6	10.0	10.4	10.9	11.3	11.7	12.2	12.6	13.1	13.5	13.9	14.4	14.8
8.0	9.8	10.2	10.6	11.1	11.5	11.9	12.4	12.8	13.3	13.7	14.1	14.6	15.0
8.2	10.0	10.4	10.8	11.3	11.7	12.1	12.6	13.0	13.5	13.9	14.3	14.8	15.2
8.4	10.2	10.6	11.0	11.5	11.9	12.3	12.8	13.2	13.7	14.1	14.5	15.0	15.4
8.6	10.4	10.8	11.2	11.7	12.1	12.5	13.0	13.4	13.9	14.3	14.7	15.2	15.6
8.8	10.6	11.0	11.4	11.9	12.3	12.7	13.2	13.6	14.1	14.5	14.9	15.4	15.8
9.0	10.8	11.2	11.6	12.1	12.5	12.9	13.4	13.8	14.3	14.7	15.1	15.6	16.0
9.2	11.0	11.4	11.8	12.3	12.7	13.1	13.6	14.0	14.5	14.9	15.3	15.8	16.2
9.4	11.2	11.6	12.0	12.5	12.9	13.3	13.8	14.2	14.7	15.1	15.5	16.0	16.4
9.6	11.4	11.8	12.2	12.7	13.1	13.5	14.0	14.4	14.9	15.3	15.7	16.2	16.6
9.8	11.6	12.0	12.4	12.9	13.3	13.7	14.2	14.6	15.1	15.5	15.9	16.4	16.8
10.0	11.8	12.2	12.6	13.1	13.5	13.9	14.4	14.8	15.3	15.7	16.1	16.6	17.0
10.2	12.0	12.4	12.8	13.3	13.7	14.1	14.6	15.0	15.5	15.9	16.3	16.8	17.2
10.4	12.2	12.6	13.0	13.5	13.9	14.3	14.8	15.2	15.7	16.1	16.5	17.0	17.4
10.6	12.4	12.8	13.2	13.7	14.1	14.5	15.0	15.4	15.9	16.3	16.7	17.2	17.6
10.8	12.6	13.0	13.4	13.9	14.3	14.7	15.2	15.6	16.1	16.5	16.9	17.4	17.8
11.0	12.8	13.2	13.6	14.1	14.5	14.9	15.4	15.8	16.3	16.7	17.1	17.6	18.0
11.5	13.3	13.7	14.1	14.6	15.0	15.4	15.9	16.3	16.8	17.2	17.6	18.1	18.5
12.0	13.8	14.2	14.6	15.1	15.5	15.9	16.4	16.8	17.3	17.7	18.1	18.6	19.0
12.5	14.3	14.7	15.1	15.6	16.0	16.4	16.9	17.3	17.8	18.2	18.6	19.1	19.5
13.0	14.8	15.2	15.6	16.1	16.5	16.9	17.4	17.8	18.3	18.7	19.1	19.6	20.0
13.5	15.3	15.7	16.1	16.6	17.0	17.4	17.9	18.3	18.8	19.2	19.6	20.1	20.5
14.0	15.8	16.2	16.6	17.1	17.5	17.9	18.4	18.8	19.3	19.7	20.1	20.6	21.0
14.5	16.3	16.7	17.1	17.6	18.0	18.4	18.9	19.3	19.8	20.2	20.6	21.1	21.5
15.0	16.8	17.2	17.6	18.1	18.5	18.9	19.4	19.8	20.3	20.7	21.1	21.6	22.0
15.5	17.3	17.7	18.1	18.6	19.0	19.4	19.9	20.3	20.8	21.2	21.6	22.1	22.5
16.0	17.8	18.2	18.6	19.1	19.5	19.9	20.4	20.8	21.3	21.7	22.1	22.6	23.0
16.5	18.3	18.7	19.1	19.6	20.0	20.4	20.9	21.3	21.8	22.2	22.6	23.1	23.5
17.0	18.8	19.2	19.6	20.1	20.5	20.9	21.4	21.8	22.3	22.7	23.1	23.6	24.0
17.5	19.3	19.7	20.1	20.6	21.0	21.4	21.9	22.3	22.8	23.2	23.6	24.1	24.5
18.0	19.8	20.2	20.6	21.1	21.5	21.9	22.4	22.8	23.3	23.7	24.1	24.6	25.0
18.5	20.3	20.7	21.1	21.6	22.0	22.4	22.9	23.3	23.8	24.2	24.6	25.1	25.5
19.0	20.8	21.2	21.6	22.1	22.5	22.9	23.4	23.8	24.3	24.7	25.1	25.6	26.0

Basic Energy Use (Table 6-7a, 6-7b, or 6-7c)	x	Climate Zone Factor (Table 6-10)	=	*Basic Energy Use to Line 2a, DHW-1*

Instructions for Instantaneous Gas Water Heaters:

1. Calculate: _____ / _____ = _____
   Adjusted Recovery Load | Recovery Efficiency (fraction) (From line 1e, DHW 1) | Recovery Energy
2. Find Basic Energy Use from table using Recovery Energy (Step 1) and Pilot Btu/hr (DHW-1, line F)
   Use nearest table values. At mid-point use higher value. **Do not interpolate.**
3. Enter Basic Energy Use in Line 2a of DHW-1

Instructions for Instantaneous Electric Water Heaters:

. Calculate: [_____] / _____ x 3 = _____
   Adjusted Recovery Load (from line 1e, DHW-1) | Energy Factor (from line D, DHW-1) | Basic Energy Use (to line 2a, DHW-1)
2. Enter Basic Energy Use on Line 2a of Worksheet DHW-1.

Note: For instantaneous electric water heaters, Energy Factor equals Recovery Efficiency.

Table 6-7E– Jacket Loss (Indirect Gas)

Tank Volume (Gallons)	Storage Tank Insulation R-value												
	12	13	14	15	16	17	18	20	22	24	26	28	30
0-19	1.1	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8
20-29	1.5	1.4	1.3	1.3	1.2	1.2	1.2	1.1	1.0	1.0	1.0	0.9	0.9
30-39	1.7	1.6	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.1	1.1	1.0	1.0
40-49	1.8	1.7	1.7	1.6	1.5	1.5	1.4	1.3	1.3	1.2	1.1	1.1	1.1
50-59	2.0	1.9	1.8	1.7	1.6	1.6	1.5	1.4	1.3	1.3	1.2	1.2	1.1
60-69	2.2	2.0	1.9	1.8	1.8	1.7	1.6	1.5	1.4	1.4	1.3	1.2	1.2
70-79	2.3	2.2	2.1	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.4	1.3	1.3
80-89	2.5	2.3	2.2	2.1	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.4	1.3
90-99	2.6	2.4	2.3	2.2	2.1	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.4
100-119	2.8	2.6	2.5	2.3	2.2	2.1	2.0	1.9	1.8	1.7	1.6	1.5	1.4
120-139	3.0	2.8	2.7	2.5	2.4	2.3	2.2	2.0	1.9	1.8	1.7	1.6	1.5
140-159	3.3	3.1	2.9	2.7	2.6	2.5	2.4	2.2	2.0	1.9	1.8	1.7	1.6
160-179	3.5	3.3	3.1	2.9	2.7	2.6	2.5	2.3	2.1	2.0	1.9	1.8	1.7
180-199	3.7	3.4	3.2	3.1	2.9	2.8	2.6	2.4	2.3	2.1	2.0	1.9	1.8
200-249	4.0	3.8	3.5	3.3	3.2	3.0	2.9	2.6	2.4	2.3	2.2	2.0	1.9
250-299	4.5	4.2	3.9	3.7	3.5	3.3	3.2	2.9	2.7	2.5	2.4	2.2	2.1
300-349	4.9	4.6	4.3	4.1	3.8	3.6	3.5	3.2	2.9	2.7	2.6	2.4	2.3
350-399	5.3	5.0	4.7	4.4	4.1	3.9	3.7	3.4	3.2	2.9	2.8	2.6	2.5
400-449	5.7	5.3	5.0	4.7	4.4	4.2	4.0	3.7	3.4	3.1	2.9	2.8	2.6
450-499	6.1	5.7	5.3	5.0	4.7	4.5	4.3	3.9	3.6	3.3	3.1	2.9	2.8
500-1000	8.0	7.4	6.9	6.5	6.1	5.8	5.5	5.0	4.6	4.3	4.0	3.7	3.5
1000	9.5	8.8	8.2	7.7	7.2	6.8	6.5	5.9	5.4	5.0	4.7	4.4	4.1

Instructions:
1. No interpolation allowed.
2. Using total insulation R-value (DHW-3, line 3) and tank volume (DHW-3, line 4), find jacket loss.
3. Enter jacket loss (JL) on line 7, DHW-3.

Table 6-8– Solar Fractions Table

		Conditioned Floor Area (ft^2)																					
		726 to 774	775 to 824	825 to 874	875 to 924	925 to 974	975 to 1049	1050 to 1149	1150 to 1249	1250 to 1349	1350 to 1449	1450 to 1549	1550 to 1649	1650 to 1749	1750 to 1849	1850 to 1949	1950 to 2049	2050 to 2149	2150 to 2249	2250 to 2349	2350 to 2499	≥2500
Solar Energy Factors	1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.1	0.16	0.15	0.15	0.15	0.14	0.14	0.14	0.13	0.13	0.12	0.12	0.12	0.11	0.11	0.10	0.10	0.10	0.10	0.09	0.09	0.09
	1.2	0.29	0.28	0.28	0.27	0.26	0.26	0.25	0.24	0.23	0.23	0.22	0.21	0.20	0.20	0.19	0.19	0.18	0.18	0.17	0.17	0.16
	1.3	0.40	0.39	0.38	0.37	0.37	0.36	0.35	0.34	0.32	0.31	0.30	0.29	0.28	0.27	0.27	0.26	0.25	0.24	0.24	0.23	0.22
	1.4	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.40	0.39	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.29	0.27
	1.5	0.57	0.56	0.55	0.54	0.53	0.52	0.50	0.48	0.47	0.45	0.44	0.42	0.41	0.40	0.38	0.37	0.36	0.35	0.34	0.33	0.32
	1.6	0.65	0.63	0.62	0.61	0.59	0.58	0.57	0.55	0.53	0.51	0.49	0.47	0.46	0.45	0.43	0.42	0.41	0.40	0.38	0.37	0.36
	1.7	0.70	0.69	0.68	0.67	0.65	0.64	0.62	0.60	0.58	0.56	0.54	0.52	0.50	0.49	0.47	0.46	0.45	0.43	0.42	0.41	0.40
	1.8	0.70	0.70	0.70	0.70	0.70	0.69	0.67	0.65	0.62	0.60	0.58	0.56	0.54	0.53	0.51	0.50	0.48	0.47	0.46	0.44	0.43
	1.9	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.66	0.64	0.62	0.60	0.58	0.56	0.55	0.53	0.51	0.50	0.49	0.47	0.45
	2.0	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.68	0.65	0.63	0.61	0.59	0.58	0.56	0.54	0.53	0.51	0.50	0.48
	2.1	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.66	0.64	0.62	0.60	0.59	0.57	0.55	0.54	0.52	0.50
	2.2	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.67	0.65	0.63	0.61	0.59	0.58	0.56	0.54	0.52
	2.3	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.67	0.65	0.63	0.61	0.60	0.58	0.56	0.54
	2.4	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.67	0.65	0.63	0.62	0.60	0.58	0.56
	2.5	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.67	0.65	0.63	0.62	0.60	0.58
	2.6	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.67	0.65	0.63	0.61	0.59
	2.7	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.68	0.66	0.65	0.63	0.60
	2.8	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.68	0.66	0.64	0.62
	2.9	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.67	0.65	0.63
	3.0	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.68	0.67	0.64
	3.1	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.68	0.65
	3.2	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69	0.66
	3.3	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.67
	3.4	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.68
	3.5	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.69
	>3.5	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70

Table 6-9– Wood Stove Boiler Credit Factors

	Credit Factors	
Climate Zone	**With Pump**	**Without Pump**
1	0.225	0.250
2	0.225	0.250
3	0.225	0.250
4	0.135	0.150
5	0.135	0.150
6	0.090	0.100
7	0.090	0.100
8	0.045	0.050
9	0.090	0.100
10	0.045	0.050
11	0.090	0.100
12	0.135	0.150
13	0.090	0.100
14	0.090	0.100
15	0.000	0.000
16	0.270	0.300

Table 6-10– Climate Zone Factors

Climate Zone	**Climate Zone Factor**
1, 14	1.04
2, 3	0.99
4, 5, 12	1.07
6-11, 13, 15	0.92
16	1.50

Case Studies

This Part explains how to demonstrate water-heating compliance for a number of common and unusual water heating systems.

Example 6-1 – Single Family, Gas Water Heater

Single family residence with one non-recirculating 40-gallon gas water heater.
This qualifies as a standard water heating system and complies automatically. No water heating calculations are required, although they may be performed to take credit for a particularly efficient water heater. See also Section 6.6.

Example 6-2 – Single Family, Heat Pump Water Heater

Single family residence with one non-recirculating 40-gallon heat pump water heater (EF=1.9) in Climate Zone 12.
Since the minimum EF for a heat pump water heater is 1.8, and this system meets that and all other requirements, it qualifies as a standard water heating system and complies automatically. No water heating calculations are required, although they may be completed at the option of the person submitting compliance documentation. See also Section 6.6.

Example 6-3 – Single Family, Two Gas Storage Tank Water Heaters

1,800 ft^2 single family residence with two identical 30-gallon gas storage tank water heaters and a point of use distribution system.

Water heating calculations are required for this system, including forms DHW-1 and DHW-2A. Form DHW-1 calculates Proposed Energy Use for the single water heater type. Credit for the Point of Use distribution system is also included on Form DHW-1. Form DHW-2A calculates the building's combined Total Proposed Energy Use, and compares it against the building's Standard Energy Use.

Example 6-4 – Single Family, Three Gas Storage Tank Water Heaters

6,000-ft^2 single family residence with 3 storage gas water heaters (40 gallon, 30 gallon and a 100-gallon unit with 80,000 Btuh input).

Water heating calculations are required for this system, including forms DHW-1, DHW-2A and DHW-3. Form DHW-1 calculates Proposed Energy Use for each individual water heater. Form DHW-3 calculates the Basic Energy Use factor for the 100-gallon water heater because its input is greater than 75,000 Btuh. Form DHW-2A calculates the building's combined Total Proposed Energy Use for the three water heaters, and compares it against the building's Standard Energy Use.

Note: Because the total floor area is greater than 2,500-ft^2, the Standard Recovery Load and Standard Energy Use for the building from Table 6-5 equal that for a 2,500-ft2 house.

Example 6-5 – Multi-family, Separate Gas Water Heaters for each Unit

10-unit multi-family building with separate gas water heaters for each dwelling unit. Five units have 30-gallon water heaters, and five units have 50-gallon water heaters.

Water heating calculations are not required if each system is non-recirculating because each dwelling unit has a standard water heating system.

Example 6-6 – Multi-family, Temperature Controlled Recirculation System

8-unit, 7,800-ft^2 multi-family building with a 200-gallon storage gas water heater and temperature controlled recirculation system serving all units.

Water heating calculations are required for this system, including forms DHW-1, DHW-2B and DHW-3. See Figure 6-3 through Figure 6-6 for the completed forms for this example.

In this situation, the correct approach is to use Form DHW-2B to calculate the average size of each dwelling unit within the building and the basic energy use per average unit.

Because a 200 gallon water heater has an input rating over 75,000 Btuh, it is necessary to use Form DHW-3 to calculate its Basic Energy Use for insertion on Line 9a of Form DHW-2B.

DHW-1 compares Proposed Energy Use to Standard Energy Use for the average dwelling unit. The Proposed Energy Use includes a penalty for the recirculation system with temperature controls.

Example 6-7 – Single Family Addition, Replacing Existing Water Heating System

Existing 1,500 ft^2 single family residence with 500 ft^2 addition. A new 50-gallon gas storage tank water heater will replace the existing water heating system.

Since this is an alteration to an existing water heating system, no water heating calculations are required. Building energy compliance for the addition may be demonstrated for either the addition alone or for the existing-plus-addition.

Example 6-8 – Single Family Existing, New Instantaneous Gas Water Heater

Existing 2,000-ft2 single family residence with one 50-gallon gas water heater; a 600 ft^2 addition with a new instantaneous gas water heater is proposed.

When there is an increase in the number of water heaters with an addition, the standards allow addition alone compliance in certain circumstances. Since this is an instantaneous gas water heater, if it can be

demonstrated that it uses no more energy than a 50-gallon gas non-recirculating storage tank (see Table 6-2), then no water heating calculations are submitted.
Another alternative is to show existing-plus-addition compliance. See Figure 6-7 and Figure 6-8 for the completed forms for this case.
Default assumptions are used for the existing water heater (see Table 6-3 for default assumptions). For the existing-plus-addition portion of the analysis, a second Form DHW-1 calculates water heater type, and Form DHW-2A calculates the building's combined Total Proposed Energy Use, and compares it against the whole building's Standard Energy Use.

Note: For instantaneous gas water heaters, Recovery Energy must be calculated using the instructions at the end of Table 6-7D before finding Basic Energy Use.

Example 6-9 – Single Family, Non-recirculating Gas Water Heater

Single family residence with one non-recirculating 50 gallon gas water heater. The water heater has an input rating of 76,000 Btu/hr.
Even though this water heater has an input rating greater than 75,000 Btu/hr, it still qualifies as a standard water heater because it is a storage gas heater of 50 gallons or less. The system still qualifies as a standard water heating system because it meets all of the stated requirements. No water heating calculations are required, and the system complies automatically. See also Section 6.6.

Example 6-10 – Single Family, Existing+Addition, Electric Water Heater

Existing single family residence with one electric water heater; a 500 ft^2 addition with a 30-gallon electric water heater is proposed.
When there is an increase in the number of water heaters with an addition, the Standards allow addition alone compliance in certain circumstances. If this residence does not have natural gas connected to the building and the new water heater has an EF of 0.90 or greater, the system automatically complies (see Table 7-2). No water heating calculations are submitted.

Example 6-11 – Single Family, Replacement Gas Water Heater

A single family residence with one gas water heater is replacing the water heater with a new gas water heater.
This system must comply with the mandatory requirements for alterations. This includes a certified water heater and pipe insulation on the first five feet of hot and cold water pipes. Since compliance with the annual water heating budget is not required, no water heating calculations are required.

Example 6-12 – Residential Building, Gas to Electric Water Heater

A residential building is replacing a gas water heating system with an electric water heating system.
In addition to complying with mandatory requirements mentioned in Example 6-12, changing from gas to electric is prohibited (see Section 7.2) unless it "can be demonstrated that the source energy use of the new system is more efficient than the existing system."
Alterations can also show compliance using an "existing-plus-alteration" compliance approach, as explained in Section 7.2. This approach could be used to take credit for improvements to the building being made to offset the water heating changes.

Figure 6-3– Example 6-6 DHW-1 Form – Multi-Family with Central System

WATER HEATING WORKSHEET — DHW-1

Multi-Family w/Central System — Project Title
July 1, 1999 — Date

No. of Different Water Heater Types: 1 Total No. of Water Heaters: 1 Conditioned Floor Area (CFA): 7800 ft2

Notes: For single family dwellings with multiple water heaters, also submit DHW-2A. For multi-family buildings, also submit DHW-2B.

Heater Type # 1 Data

A. **Water Heater Type** (check one)
- ___ Storage Gas
- ✓ Large Storage Gas
- ___ Storage Electric
- ___ Storage Heat Pump
- ___ Instantaneous Gas
- ___ Instantaneous Electric
- ___ Indirect Gas

B. **Manufacturer** SoHot
C. **Model No.** G200
D. **Energy Factor** NA
E. **Gallons** 200
F. **Pilot Btu/hr** NA
G. Thermal **Eff.** 0.78

H. **Auxiliary Input** (check one or both)
- ___ Wood Stove
- ___ Solar, Active or Passive

I. **Distribution System** (check one)
- ___ Standard
- ___ Hot Water Recovery (HWR)
- ___ Point of Use (POU)
- ___ Pipe Insulation (PI)
- ___ Recirculation: No Control
- ___ Recirculation: Timer
- ✓ Recirculation: Temp.
- ___ Recirculation: Time/Temp.
- ___ Recirculation: Demand
- ___ HWR + Recirculation: Demand
- ___ PI + Recirculation: Demand

Energy Use Calculation

1a. Standard Recovery Load (from Table 6-5 or DHW 2a or 2b)	9.7
1b. Distribution Credit/Penalty (from Table 6-6)	-0.5
1c. Solar Energy Credit (from DHW-4)	0
1d. Adjusted Recovery Load (1a - 1b - 1c)	10.2
2a. Basic Energy Use (from Table 6-7)	16.7
2b. Wood Stove Boiler Credit (from DHW-4)	0
2c. **Proposed Energy Use** (2a - 2b)	16.7
3. **Standard Energy Use** (from Table 6-5)	18.8

Heater Type #_____ Data

A. **Water Heater Type** (check one)
- ___ Storage Gas
- ___ Large Storage Gas
- ___ Storage Electric
- ___ Storage Heat Pump
- ___ Instantaneous Gas
- ___ Instantaneous Electric
- ___ Indirect Gas

B. **Manufacturer** _____
C. **Model No.** _____
D. **Energy Factor** _____
E. **Gallons** _____
F. **Pilot Btu/hr** _____
G. Thermal **Eff.** _____

H. **Auxiliary Input** (check one or both)
- ___ Wood Stove
- ___ Solar, Active or Passive

I. **Distribution System** (check one)
- ___ Standard
- ___ Hot Water Recovery (HWR)
- ___ Point of Use (POU)
- ___ Pipe Insulation (PI)
- ___ Recirculation: No Control
- ___ Recirculation: Timer
- ___ Recirculation: Temp.
- ___ Recirculation: Time/Temp.
- ___ Recirculation: Demand
- ___ HWR + Recirculation: Demand
- ___ PI + Recirculation: Demand

Energy Use Calculation

1a. Standard Recovery Load (from Table 6-5 or DHW 2a or 2b)	
1b. Distribution Credit/Penalty (from Table 6-6)	
1c. Solar Energy Credit (from DHW-4)	
1d. Adjusted Recovery Load (1a - 1b - 1c)	
2a. Basic Energy Use (from Table 6-7)	
2b. Wood Stove Boiler Credit (from DHW-4)	
2c. **Proposed Energy Use** (2a - 2b)	
3. **Standard Energy Use** (from Table 6-5)	

Heater Type #_____ Data

A. **Water Heater Type** (check one)
- ___ Storage Gas
- ___ Large Storage Gas
- ___ Storage Electric
- ___ Storage Heat Pump
- ___ Instantaneous Gas
- ___ Instantaneous Electric
- ___ Indirect Gas

B. **Manufacturer** _____
C. **Model No.** _____
D. **Energy Factor** _____
E. **Gallons** _____
F. **Pilot Btu/hr** _____
G. Thermal **Eff.** _____

H. **Auxiliary Input** (check one or both)
- ___ Wood Stove
- ___ Solar, Active or Passive

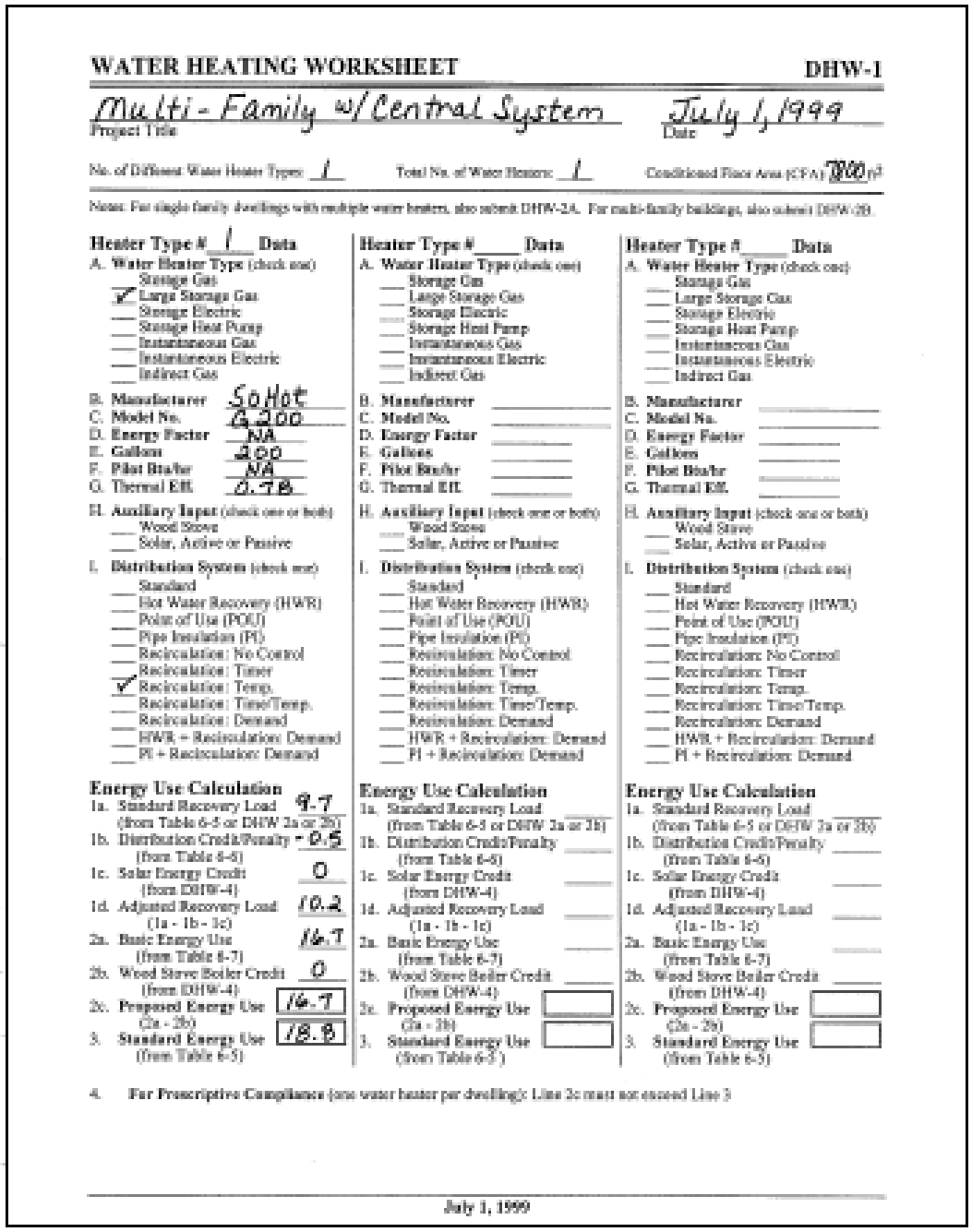
I. **Distribution System** (check one)
- ___ Standard
- ___ Hot Water Recovery (HWR)
- ___ Point of Use (POU)
- ___ Pipe Insulation (PI)
- ___ Recirculation: No Control
- ___ Recirculation: Timer
- ___ Recirculation: Temp.
- ___ Recirculation: Time/Temp.
- ___ Recirculation: Demand
- ___ HWR + Recirculation: Demand
- ___ PI + Recirculation: Demand

Energy Use Calculation

1a. Standard Recovery Load (from Table 6-5 or DHW 2a or 2b)	
1b. Distribution Credit/Penalty (from Table 6-6)	
1c. Solar Energy Credit (from DHW-4)	
1d. Adjusted Recovery Load (1a - 1b - 1c)	
2a. Basic Energy Use (from Table 6-7)	
2b. Wood Stove Boiler Credit (from DHW-4)	
2c. **Proposed Energy Use** (2a - 2b)	
3. **Standard Energy Use** (from Table 6-5)	

4. **For Prescriptive Compliance** (one water heater per dwelling): Line 2c must not exceed Line 3

Figure 6-4– Example 6-6 DHW-1 Form – Multi-Family with Central System



WATER HEATING WORKSHEET **DHW-1**

Multi-Family w/Central System — Project Title
July 1, 1999 — Date

No. of Different Water Heater Types: 1 Total No. of Water Heaters: 1 Conditioned Floor Area (CFA): 900 ft²

Notes: For single family dwellings with multiple water heaters, also submit DHW-2A. For multi-family buildings, also submit DHW-2B.

Heater Type # 1 Data	Heater Type # ____ Data	Heater Type # ____ Data
A. Water Heater Type (check one)	A. Water Heater Type (check one)	A. Water Heater Type (check one)
___ Storage Gas	___ Storage Gas	___ Storage Gas
✓ Large Storage Gas	___ Large Storage Gas	___ Large Storage Gas
___ Storage Electric	___ Storage Electric	___ Storage Electric
___ Storage Heat Pump	___ Storage Heat Pump	___ Storage Heat Pump
___ Instantaneous Gas	___ Instantaneous Gas	___ Instantaneous Gas
___ Instantaneous Electric	___ Instantaneous Electric	___ Instantaneous Electric
___ Indirect Gas	___ Indirect Gas	___ Indirect Gas
B. Manufacturer SoHot	B. Manufacturer	B. Manufacturer
C. Model No. A200	C. Model No.	C. Model No.
D. Energy Factor NA	D. Energy Factor	D. Energy Factor
E. Gallons 200	E. Gallons	E. Gallons
F. Pilot Btu/hr NA	F. Pilot Btu/hr	F. Pilot Btu/hr
G. Thermal Eff. 0.78	G. Thermal Eff.	G. Thermal Eff.
H. Auxiliary Input (check one or both)	H. Auxiliary Input (check one or both)	H. Auxiliary Input (check one or both)
___ Wood Stove	___ Wood Stove	___ Wood Stove
___ Solar, Active or Passive	___ Solar, Active or Passive	___ Solar, Active or Passive
I. Distribution System (check one)	I. Distribution System (check one)	I. Distribution System (check one)
___ Standard	___ Standard	___ Standard
___ Hot Water Recovery (HWR)	___ Hot Water Recovery (HWR)	___ Hot Water Recovery (HWR)
___ Point of Use (POU)	___ Point of Use (POU)	___ Point of Use (POU)
___ Pipe Insulation (PI)	___ Pipe Insulation (PI)	___ Pipe Insulation (PI)
___ Recirculation: No Control	___ Recirculation: No Control	___ Recirculation: No Control
___ Recirculation: Timer	___ Recirculation: Timer	___ Recirculation: Timer
✓ Recirculation: Temp.	___ Recirculation: Temp.	___ Recirculation: Temp.
___ Recirculation: Time/Temp.	___ Recirculation: Time/Temp.	___ Recirculation: Time/Temp.
___ Recirculation: Demand	___ Recirculation: Demand	___ Recirculation: Demand
___ HWR + Recirculation: Demand	___ HWR + Recirculation: Demand	___ HWR + Recirculation: Demand
___ PI + Recirculation: Demand	___ PI + Recirculation: Demand	___ PI + Recirculation: Demand
Energy Use Calculation	**Energy Use Calculation**	**Energy Use Calculation**
1a. Standard Recovery Load (from Table 6-5 or DHW 2a or 2b) 9.7	1a. Standard Recovery Load (from Table 6-5 or DHW 2a or 2b)	1a. Standard Recovery Load (from Table 6-5 or DHW 2a or 2b)
1b. Distribution Credit/Penalty (from Table 6-6) -0.5	1b. Distribution Credit/Penalty (from Table 6-6)	1b. Distribution Credit/Penalty (from Table 6-6)
1c. Solar Energy Credit (from DHW-4) 0	1c. Solar Energy Credit (from DHW-4)	1c. Solar Energy Credit (from DHW-4)
1d. Adjusted Recovery Load (1a - 1b - 1c) 10.2	1d. Adjusted Recovery Load (1a - 1b - 1c)	1d. Adjusted Recovery Load (1a - 1b - 1c)
2a. Basic Energy Use (from Table 6-7) 14.7	2a. Basic Energy Use (from Table 6-7)	2a. Basic Energy Use (from Table 6-7)
2b. Wood Stove Boiler Credit (from DHW-4) 0	2b. Wood Stove Boiler Credit (from DHW-4)	2b. Wood Stove Boiler Credit (from DHW-4)
2c. Proposed Energy Use (2a - 2b) 14.7	2c. Proposed Energy Use (2a - 2b)	2c. Proposed Energy Use (2a - 2b)
3. Standard Energy Use (from Table 6-5) 18.8	3. Standard Energy Use (from Table 6-5)	3. Standard Energy Use (from Table 6-5)

4. **For Prescriptive Compliance** (one water heater per dwelling): Line 2c must not exceed Line 3

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Figure 6-5– Example 6-6 DHW-2B Form – Multi-Family with Central System

WATER HEATING FOR MULTI-FAMILY BUILDINGS **DHW-2B**

Multi-Family w/Central System — Project Title

July 1, 1999 — Date

Notes: In addition to this form, a DHW-1 Water Heating Worksheet must also be submitted to document water heating type(s). If the calculation (line 4) is by "Individual Dwelling Unit" and system configuration (line 5) is "Individual Heaters," no additional information need be entered on this sheet.

Multi-Family Project Data

1. Number of dwelling units: 8
2. Total conditioned floor area: 7800 ft²
3. Average floor area: 975 (Line 2/Line 1)
4. Calculation by (check one): ✓ Average Dwelling Unit ___ Individual Dwelling Unit
5. System configuration (check one): ___ Individual Heaters (one per dwelling unit) ✓ Shared Heaters (multiple dwelling units per heater)

Analysis by Average Dwelling Unit

One Individual Heater Per Dwelling Unit

	No. of Heaters	Heater Type#	Manufacturer and Model#	Gallons Each	Gallons Total[1]	Energy Factor Each	Energy Factor Total[2]	Thermal Efficiency Each	Thermal Efficiency Total[3]
8a =	1	#1	SoHot G200						
8b =		#2							
8c =		#3							
Total	1	= 7a		Total ___	= 7b	Total ___	= 7c	Total ___	= 7d
				Ave. ___	= 8a	Ave. ___	= 8b	Ave. ___	= 8c
				(7b/7a)		(7c/7a)		(7d/7a)	

Individual Heaters

9a. Enter value 8a on DHW-1 Line E.
10a. Enter value 8b on DHW-1 Line D.
11a. Enter value 8c on DHW-1 line G.
12a. Check compliance on DHW-1 for average dwelling unit and average water heating.

Shared Heater(s)

9b. Average unit Adjusted Recovery Load: 10.2 From DHW-1, Line 1d

10b. Total Adjusted Recovery Load: 81.6 (Line 1) × (Line 9b)

11b. Total Basic Energy Use: 93.8 From Table 6-7, or DHW-3

12b. Average Unit Basic Energy Use: 11.7 (Line 11b) ÷ (Line 1); enter on Line 2a, DHW-1

13b. Check average unit compliance on DHW-1.

Compliance

14. **Prescriptive Compliance** (for individual or shared heaters):
DHW-1 Line 2c must be equal to or less than DHW-1 Line 3.
See Part 6.1 and Chapter 3 in the *Residential Manual* for details.

[1] Total Gallons = (No. of Heaters) x (Gallons for each heater of this Heater Number)
[2] Total Energy Factor = (No. of Heaters) x (Energy Factor for each heater of this Heater Number)
[3] Total Thermal Efficiency = (No. of Heaters) x (Thermal Efficiency for each heater of this Heater Number)

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Figure 6-6– Example 6-6 DHW-3 Form – Multi-Family with Central System

INDIRECT & LARGE STORAGE GAS WATER HEATERS **DHW-3**

Multi-Family w/Central System — Project Title
July 1, 1999 — Date

Note: This sheet must also be submitted with a DHW-1 water heating worksheet, as well as a DHW-2B form with large storage gas heaters in multi-family buildings.

Indirect Gas Water Heaters

1.	Storage tank Manufacturer/Model No.		
2.	Boiler and Instantaneous Heater Manufacturer/Model No.		
3.	Storage tank insulation R-value: Tank _____ External _____	Total	_____
4.	Storage tank volume (gallons)		_____
5.	Boiler AFUE or Instantaneous Water Heater Thermal (Recovery) Efficiency	EFF	_____
6.	Adjusted Recovery Load (MBtu/yr, from Line 1d, DHW-1)	ARL	_____
7.	Jacket loss (MBtu/yr, from Table 6-7E)	JL	_____
8.	Pilot Energy (Btuh, from appliance database, or use 800)	PE	_____
9.	Basic Energy Use (BEU) = (ARL + JL) ÷ (0.98 × EFF) + (PE × 0.00876) (Enter BEU on DHW-1, Line 2a or on DHW-2B, Line 11b)	BEU	_____

Large Storage Gas Heaters (> 75,000 Btuh input)

1.	Water Heater Manufacturer	So Hot	
2.	Water Heater Model No.	G200	
3.	Storage Tank Volume (gallons)	VOL=	200
4.	Water Heater Thermal (Recovery) Efficiency (decimal fraction)	EFF	0.78
5.	Adjusted Recovery Load (Mbtu/yr, from Line 1d, DHW-1 or Line 10b, DHW-2B)	ARL	81.6
6.	Standby Loss % (from appliance database - e.g., "2.7")	SBL%	2.5
7.	Basic Energy Use (BEU) = [ARL/EFF + (5.461 × SBL×VOL)/100] (Enter BEU on DHW-1, Line 2a or on DHW-2B, Line 11b)	BEU	133.5

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Figure 6-7– Example 6-8 DHW-1 for Existing + Addition

WATER HEATING WORKSHEET — DHW-1

Jones Residence: Existing & Addition — Project Title

July 1, 1999 — Date

No. of Different Water Heater Types: 2 — Total No. of Water Heaters: 2 — Conditioned Floor Area (CFA): 2600 ft²

Notes: For single family dwellings with multiple water heaters, also submit DHW-2A. For multi-family buildings, also submit DHW-2B.

	Heater Type # 1 Data	Heater Type # 2 Data	Heater Type # ____ Data
A. Water Heater Type (check one)	✓ Storage Gas	✓ Instantaneous Gas	
B. Manufacturer	So Hot	GTherm	
C. Model No.	G40	I.00	
D. Energy Factor	0.40	NA	
E. Gallons	40	NA	
F. Pilot Btu/hr	NA	300	
G. Thermal Eff.	NA	0.80	
H. Auxiliary Input (check one or both)			
I. Distribution System (check one)	✓ Standard	✓ Standard	
Energy Use Calculation			
1a. Standard Recovery Load (from Table 6-5 or DHW 2a or 2b)	7.8	7.8	
1b. Distribution Credit/Penalty (from Table 6-6)	0	0	
1c. Solar Energy Credit (from DHW-4)	0	0	
1d. Adjusted Recovery Load (1a - 1b - 1c)	7.8	7.8	
2a. Basic Energy Use (from Table 6-7)	15.7	12.4	
2b. Wood Stove Boiler Credit (from DHW-4)		0	
2c. Proposed Energy Use (2a - 2b)		12.4	
3. Standard Energy Use (from Table 6-5)	—	—	

4. For Prescriptive Compliance (one water heater per dwelling): Line 2c must not exceed Line 3

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Figure 6-8– Example 6-8 DHW-2A for Existing + Addition

SINGLE FAMILY W/ MULTIPLE WATER HEATERS **DHW-2A**

Jones Residence : Existing + Addition (Project Title) July 1, 1999 (Date)

Note: In addition to this form, a DHW-1 Water Heating Worksheet must also be submitted to document water heater type(s).

Single Family Project Data

1. No. of different water heater types: 2
2. Total conditioned floor area: 2500 ft²

	No. of Heaters	Heater Type #	Manufacturer & Model No.
3a.	1	#1	SoHot G40
3b.	1	#2	GTherm I00
3c.		#3	

4. 2 Total Number of Water Heaters
5. Standard Recovery Load: 15.6 from Table 6-5 based on line 2
6. Recovery Load Per Heater: 7.8 (line 5 ÷ line 4); enter on DHW-1, line 1a for each Heater Type, and complete calculation through line 2c.
7. Proposed Energy Use, Heater #1: 15.7 (from DHW-1 line 2c, Heater #1) × (line 3a)
8. Proposed Energy Use, Heater #2: 10.4 (from DHW-1 line 2c, Heater #2) × (line 3b)
9. Proposed Energy Use, Heater #3: — (from DHW-1 line 2c, Heater #3) × (line 3c)
10. Total Proposed Energy Use: 26.1 (line 7 + line 8 + line 9)
11. Standard Energy Use: 26.1 from Table 6-5 based on line 2

Compliance

12. **Prescriptive Compliance:** Line 10 must be equal to or less than line 11. See Part 6.1 and Chapter 3 in the *Residential Manual* for details.

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Combined Hydronic Space and Water Heating

Section 8.9 explains hydronic space heating systems. When such a system serves the additional function of providing domestic hot water, the system is analyzed for its water heating performance as if the space heating function were separate. In other words, treat any hydronic system used for water heating the same as any other water heating system: Input the correct water heater type, auxiliary input credit (if any) and specify the distribution system on DHW-1.

The DHW-5 is used to calculate an effective AFUE or to adjust the AFUE for pipe losses when a space heating boiler is also used for water heating (see Section 6.3).

Complete the DHW-5 worksheet for any project that includes a hydronic space heating system, combined hydronic space and water heating system, or boiler (see Section 6.3). This worksheet should accompany all necessary water heating compliance worksheets. The DHW-5 worksheet is used to determine the Effective AFUE for storage gas water heaters and the Effective HSPF for storage electric and heat pump water heaters used to supply energy for the combined hydronic space and water heating system.

For performance compliance, the water heating worksheets are not printed, but the inputs will appear on the C-2R and CF-1R forms.

System Descriptions

System Types and Installation

The water heating calculation method evaluates water heating systems by analyzing the following system components: Water Heaters, Auxiliary Systems, and Distribution Systems. Separate calculations are required for Hydronic Space and Water Heating Systems. This part describes all of the system types that fall within each category, and explains installation criteria.

Water Heaters

This part describes water heater types that can be analyzed using the water heating method:

- Standard Water Heater
- Storage Gas
- Large Storage Gas
- Storage Electric
- Storage Heat Pump
- Instantaneous Gas
- Instantaneous Electric
- Indirect Gas

All water heaters must be certified (see Section 1.6). This guarantees that they meet the minimum requirements of the National Efficiency Standards and State Efficiency Standards as described in the California Appliance Efficiency Regulations.

For small storage gas water heaters this corresponds to an Energy Factor = 0.62 - (0.0019 x Volume).

For small storage electric water heaters the minimum is an Energy Factor = 0.93 - (0.00132 x Volume).

Standard Water Heater

A standard water heater is one that automatically complies with the standards, since its characteristics meet the installation criteria described below. For a system in a single family dwelling consisting of a single standard water heater and a standard distribution system, compliance is demonstrated by listing water heater type and distribution system on form CF-1R. No other water heating calculations are required.

Installation Criteria:

One gas water heater of 50-gallons capacity or less per dwelling unit. On any unit with an EF of less than 0.58, R-12 external insulation is mandatory.

Storage Gas

A gas water heater designed to heat and store water at less than 180°F. Water temperature is controlled with a thermostat. Storage gas water heaters have a manufacturer's specified storage capacity of at least two gallons and less than 75,000 Btuh input.

Large Storage Gas

A storage gas water heater with greater than 75,000 Btuh input.

Storage Electric

An electric water heater designed to heat and store water at less than 180 °F. Water temperature is controlled with a thermostat. Storage electric water heaters have a manufacturer's specified storage capacity of at least two gallons.

Storage Heat Pump

An electric water heater that uses a compressor to transfer thermal energy from one temperature level to a higher temperature level for the purpose of heating water. It includes all necessary auxiliary equipment such as fans, storage tanks, pumps or controls. EFs for heat pump water heaters are found in the Commission's Directory of Certified Water Heaters.

Instantaneous Gas

A gas water heater controlled manually or automatically by a water flow activated control or a combination of water flow and thermostatic controls, with a manufacturer's specified storage capacity of less than two gallons.

Recovery efficiency and pilot energy are in the Commission's database of certified water heaters.

Instantaneous Electric

An electric water heater controlled automatically by a thermostat, with a manufacturer's specified storage capacity of less than two gallons.

Note: Instantaneous water heaters are not generally designed for use with solar water heating systems or as heat sources for indirect fired water heaters. They are also typically inappropriate for use with recirculation systems. Consult manufacturer's literature when considering these applications.

Indirect Gas

A water heater consisting of a storage tank with no heating elements or combustion devices, connected via piping and recirculating pump to a heat source consisting of a gas or oil fired boiler, or instantaneous gas water heater (see note following the definitions of Instantaneous Gas and Electric).

Installation Criteria:

The storage tank must be insulated in accordance with Section 150(j)1.B. of the standards, which requires a factory-installed minimum of R-16 (labeled on outside of tank) or a minimum of R-12 external insulation (see Section 2.6).

The piping connecting the heating source and the storage tank must be insulated to R-4 for pipe less than or equal to 2 inches in diameter, and to R-6 for pipes larger than 2 inches in diameter. This includes any piping located in concrete slabs or underground.

External Tank Insulation

Insulation applied to the exterior of storage type water heater tanks.

When installed, water heater insulation should be applied to completely cover the exterior sides of water heaters, but should not conceal controls or access ports to burners, cover combustion air openings, or interfere in any way with safe water heater operation. Insulation of top and bottom surfaces is not necessary.

External tank insulation is mandatory for water heaters with less than 0.58 EF, and for unfired water heater tanks that do not have R-16 internal insulation (as indicated on the outside of the tank).

Auxiliary Systems

Auxiliary systems add hot water to the overall water heating system through means other than the typical water heaters defined above.

The Water Heating Calculation Method allows water heating credits for three auxiliary systems which save energy by using nondepletable resources as energy sources. These systems – Passive and Active Solar Water Heaters and Wood Stove Boilers – are described below.

Passive Solar Water Heaters

Systems which collect and store solar thermal energy for domestic water heating applications and do not require electrical energy input for recirculating water through a solar collector.

Installation Criteria:

Passive solar water heaters must be tested in accordance with Solar Rating & Certification Corporation (SRCC) Standard 200-82, except as noted below.

Thermosyphon solar water heaters employing flat plate collectors comply with test requirements if collectors are tested in accordance with SRCC Standard 100-81.

SRCC's address is:

Solar Rating and Certification Corporation
C/o FSEC, 1679 Clearlake Road
Cocoa, FL 32922-5703
(407) 638-1537
(407) 638-1010 (FAX)

Active Solar Water Heaters

Systems which collect and store solar thermal energy for domestic water heating applications requiring electrical energy input for operation of pumps or other components.

Installation Criteria:

Flat plate collectors used with active solar waters must be tested in accordance with SRCC Standard 100-81 (see address above).

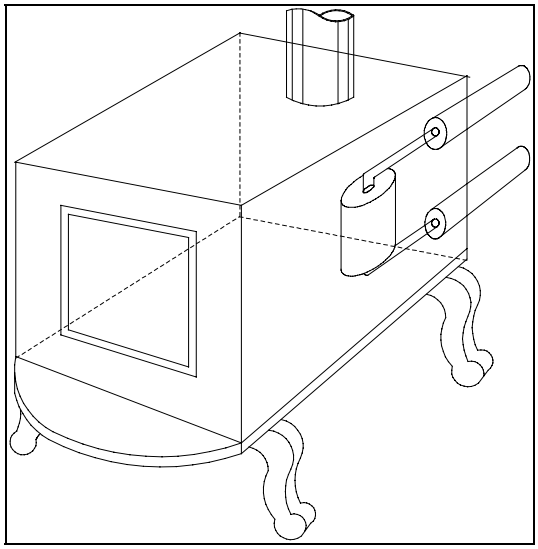
Wood Stove Boilers

Wood stoves equipped with heat exchangers for heating domestic hot water (see Figure 6-9).

Installation Criteria:

Energy credits may only be taken when the building department having jurisdiction has determined that natural gas is not available.

Figure 6-9– Wood Stove Boiler



A tempering valve must be installed at the outlet of the water heater to prevent scalding.

A pressure-temperature relief valve must be installed at the wood stove.

The wood stove boiler must be properly sized to minimize the amount of excess hot water produced by the unit.

All health and safety codes, including codes applying to pressurized boiler vessels, must be met.

Distribution Systems

The water heating distribution system is the configuration of piping, pumps and controls that regulates delivery of hot water from the water heater to all end uses within the building.

All criteria listed below are based on Commission contract #400-88-003, *Residential Water Heating Study*: March 31, 1991.

The water heating calculation method gives credits for especially energy-efficient distribution systems, while taking penalties for less energy-efficient systems (see Table 6-3). The distribution systems that may be analyzed are:

- Standard Distribution System
- Point of Use
- Hot Water Recovery
- Pipe Insulation
- Parallel Piping
- Recirculation: Continuous
- Recirculation: Temperature Controlled
- Recirculation: Time Controlled
- Recirculation: Time & Temperature Controlled
- Recirculation: Demand Pumping
- Hot Water Recovery + Recirculation: Demand Pumping
- Pipe Insulation + Recirculation: Demand Pumping

Only one distribution system type may be chosen for each water heating system, with the exception of recirculation systems with demand pumping which may be combined with **either** hot water recovery systems **or** pipe insulation. In either of these cases the two appropriate adjustment values from Table 6-6 are added together and input as Distribution Credit on form DHW-1.

Pipe insulation is required for all other recirculation systems (except Demand) and may not be used for extra credit (see Section 2.6).

Standard Distribution System

A standard distribution system does not incorporate a pump for recirculation of hot water, and does not take credit for any design features eligible for energy credits. A distribution system normally eligible for energy credits, such as one with pipe insulation, may be modeled as standard (i.e., no credits) to avoid the need for any water heating calculations.

Compliance for any water heating system in a single family house with standard distribution and only one standard water heater is demonstrated by listing the water heater type and distribution system on form CF-1R. No other water heating forms are required.

Installation Criteria:

No pumps may be used to recirculate hot water. The first five feet of hot and cold water piping adjacent to the water heater must be insulated with minimum R-4 insulation (see Section 2.6).

Point of Use

A distribution piping system that limits hot water distribution system heat loss by minimizing the distance between the water heater and hot water fixtures.

Credit for only one Point of Use may be taken even if additional water heaters meeting the criteria will be installed.

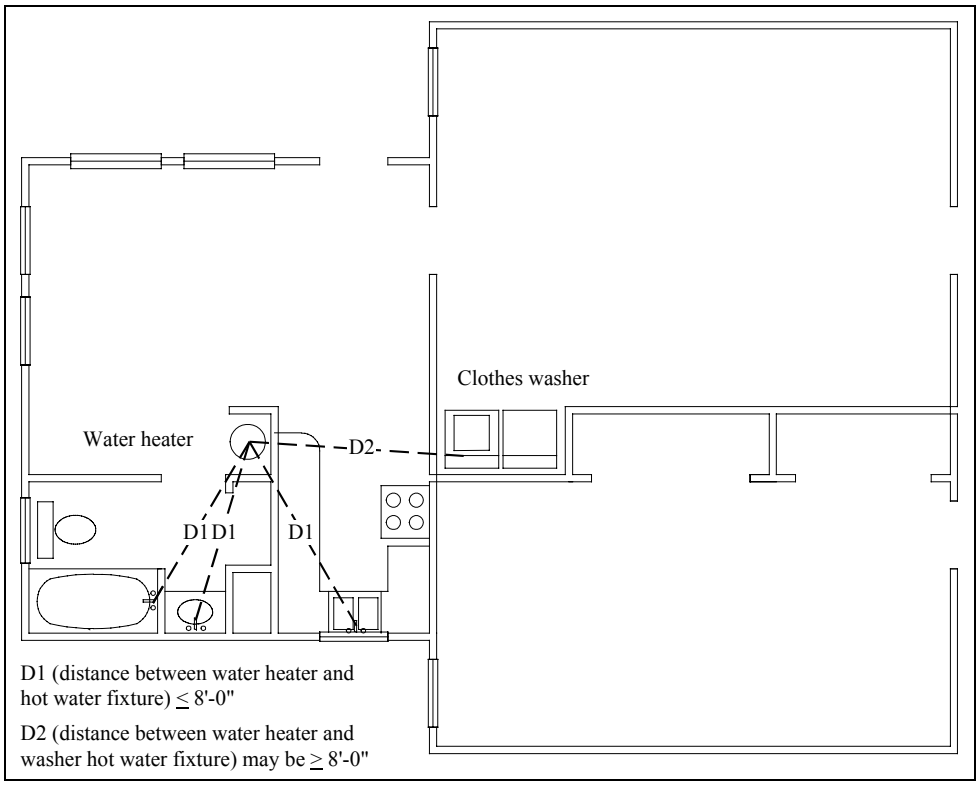
Installation Criteria:

The distance between the water heater and any hot water fixture cannot exceed eight feet, measured in plan view (see Figure 6-10).

All water heaters and hot water fixtures must be shown on plans submitted for local building department plan check.

EXCEPTION: Washing machines for clothing may be located more than eight feet from the water heater.

Figure 6-10– Point of Use



Hot Water Recovery System
A distribution system that includes a device that reclaims hot water from the distribution piping by drawing it back to the water heater or other insulated storage vessel.
Installation Criteria:
Hot water recovery systems (HWR) must be plumbed such that a positive supply of cold water from the water supply main is provided to the appropriate connection on the device.
Hot water recovery systems must be connected to each water heater serving individual dwelling units. Credit for only one HWR may be taken even though more than one may be installed or specified in the building plans.
Credit may not be taken for a HWR in a multi-family central water heating system serving multiple dwelling units.
Hot water recovery systems may be used for credit in recirculation systems with demand pumping.

Pipe Insulation
Table 6-3 lists credits that may be taken for insulation of water mains in addition to insulation required by Section 150 of the Standards (first five feet from water heater). The pipe insulation credit is only allowed for 3/4 inch or larger, non-recirculating hot water mains and Demand Recirculating Systems.
Installation Criteria:
R-value of applied insulation must not be less than R-4.0, or less than R-6.0 for pipe diameters greater than 2 inches. No additional credit may be taken for R-4 or R-6 insulation, respectively (see Section 2.6.2).
Pipe insulation may only be used for credit in recirculation systems with demand pump. *Pipe insulation is required for all other recirculation systems and is not eligible for credit.*

Note: Heat tape – electric resistance heating tape wrapped around hot water pipes – may be used only for freeze protection and cannot be used instead of mandatory pipe insulation (see Section 2.6.2) or pipe insulation receiving distribution credit.

Parallel Piping
A distribution system that limits the amount of heat loss and water lost from the distribution piping by minimizing the volume of hot water left in the pipes at the end of each water draw.

Credit for Parallel Piping can only be used if each hot water use location (each kitchen, each bathroom and each laundry area) has a separate distribution line with a maximum size of half-inch pipe run from the location of the water heater to each hot water use location.
Installation Criteria:
Adequate distribution piping must be supplied to meet the demand at each hot water use location as required by the plumbing code. No piping over one-half inch may be used with the exception of a manifold located within six feet of the water heater to which the half-inch piping runs are connected.
All water heaters, distribution line runs and fixture points must be shown on the plans.

Recirculation System
Continuous distribution system using a pump to recirculate hot water to branch piping though a looped hot water main with no control of the pump, such that water flow is continuous.
Installation Criteria:
All piping used to recirculate hot water must be insulated with R-4 insulation or equivalent. This includes any recirculating piping located in concrete slabs or underground. Since the standards require this insulation, it is not eligible for the Pipe Insulation credit.

Recirculation System: Temperature Controlled
Recirculation system that uses temperature controls to cycle pump operation to maintain circulated water temperatures within certain limits.
Installation Criteria:
All criteria listed for continuous recirculation systems apply.
An automatic thermostatic control must be installed to cycle the pump on and off in response to the temperature of water returning to the water heater through the recirculation piping. Minimum differential or "deadband" of the control shall not be less than 20°F.
Plans must indicate pump and control manufacturer, model number and temperature settings.

Recirculation System: Time Controlled
Recirculation system that uses a timer control to cycle pump operation based on time of day.
Installation Criteria:
All criteria listed for continuous recirculation systems apply.
A timer must be permanently installed to regulate pump operation. Timer setting must permit the pump to be cycled off for at least eight hours per day.
Plans must indicate pump and timer manufacturer and model number.

Recirculation System: Time and Temperature Controlled
Recirculation system that uses both temperature and timer controls to regulate pump operation.
Installation Criteria:
All criteria listed for continuous, temperature controlled, and timer controlled recirculation systems apply.

Recirculation System: Demand Pumping
Recirculation system that uses brief pump operation to recirculate hot water to fixtures on demand.
Installation Criteria:
All criteria listed for continuous recirculation systems apply, except that pipe insulation is not required.
Pump start-up must be provided by one or more momentary contact switches, or a hot water flow sensing device located at the water heater. Systems using momentary contact switches must have at least one switch at each floor level, one of which must be located at the kitchen sink.
Pump shut-off must be provided by either a temperature sensing device that shuts off the pump when the pipe is full of hot water, or by a timer which limits pump run time to two minutes or less.
Plans must include a wiring/circuit diagram, and manufacturer/model numbers for the pump and timer/temperature sensing device.
Demand systems can only be used for control of pumps serving one dwelling unit. They are not used for central systems in multi-family buildings.

Note: In an exception to the rule that distribution systems may not be combined, insulation *or* hot water recovery systems may be used for credit in recirculation systems with demand pumping (see below). Pipe insulation is required for all other recirculation systems, so it is not eligible for extra credit.
Recirculation systems are not used with instantaneous water heaters.

Hot Water Recovery + Recirculation System: Demand Pumping
This combination system receives both credits explained under each system, separately, above. Installation criteria for both credits – hot water recovery and demand recirculation – apply to this combined distribution type.

Pipe Insulation + Recirculation System: Demand Pumping
This combination system receives both credits explained under each system, separately, above. Installation criteria for both credits – pipe insulation and demand recirculation – apply to this combined distribution type.

Hydronic Space and Water Heating

Combined Hydronic Space and Water Heating
A combined water and space heating system using the same water heater to heat the building and to provide domestic hot water.
Installation Criteria:
Piping for pump recirculating hydronic space heating supply lines must be insulated to R-4 for pipes less than or equal to 2 inches nominal diameter and R-6 for larger pipe diameters.

Dedicated (Separate) Hydronic Space Heating
A system using separate water heaters to provide space heating and domestic hot water, each dedicated to one function.
Installation Criteria:
Piping for pump recirculating hydronic space heating supply lines must be insulated to R-4.0 for pipes 2 inches or less in diameter and to R-6.0 for larger pipe diameters. See the standards, §150(j).

Residential Lighting

Kitchen Lighting


§150(k)1, 3

1. *Luminaires for general lighting in kitchens shall have lamps with an efficacy of not less than 40 lumens per watt. General lighting must provide a sufficient light level for basic kitchen tasks and provide a uniform pattern of illumination. A luminaire(s) that is(are) the only lighting in a kitchen will be considered general lighting. General lighting shall be controlled by a switch on a readily accessible lighting control panel at an entrance to the kitchen.*
2. *Additional luminaires to be used only for specific decorative effects need not meet this requirement.*
3. *Luminaires installed to meet the 40 lumens per watt requirements of Section 150(k) 1. or 2. shall not contain medium base incandescent lamp sockets, and shall be on separate switches from any incandescent lighting.*

Installing energy-efficient lamps and fixtures can reduce lighting energy costs without sacrificing the quality or quantity of light available. The intent of the kitchen lighting code is not to increase the number of light fixtures and/or watts used by the occupant but rather to ensure that the builder provides - and the occupant uses - energy efficient lighting. As indicated in Table 2-5, a 40-watt standard fluorescent lamp is over four times as efficient as a 100-watt standard incandescent lamp ('efficacy' is defined in §101(b) of the Standards as, "…the ratio of light from a lamp to the electrical power consumed (including ballast losses) expressed in lumens per watt").
General lighting is the lighting that the occupant will typically use on a regular basis (normally, but not necessarily, fluorescent lighting). If there is only one light in the kitchen, it is general lighting. IES guidelines recommend that at least 30 footcandles of light be provided for seeing tasks in kitchens. Seeing tasks include, but are not limited to, basic kitchen tasks such as preparing meals and washing dishes. These tasks typically occur on accessible kitchen countertops, the tops of ranges and in sinks, where food preparation, recipe reading, cooking, cleaning and related meal preparation activities take place, as well as at the front of kitchen cabinets.

The general lighting in kitchens must:

- Have an efficacy of *at least 40 lumens/watt* (see Table 2-5).
- Provide a uniform pattern of lighting, such as a fixture in the center of the kitchen or

around the perimeter (not a fixture in the corner).

- Provide a light level sufficient for performing basic kitchen tasks such as preparing meals and washing dishes.
- Be controlled on a readily accessible switch at an entrance to the kitchen (not in a cupboard or beside the kitchen sink).
- Be switched independent of incandescent lighting.
- Shall nNot contain medium-base incandescent lamp sockets. This prevents the occupant from replacing the efficient light source with an incandescent bulb.

Additional luminaires for decorative effect do not need to meet these requirements.

Incandescent lighting fixtures recessed into insulated ceilings must be approved for zero-clearance insulation cover (IC-rated) in compliance with §150(k)4 (see below).

The lighting in the kitchen, either general or the only lighting, must:

- Be fluorescent or another product that has at least 40 lumens/watt (see Table 2-5).
- Provide a uniform pattern of lighting, such as a fixture in the center of the kitchen or around the perimeter (not a fixture in the corner).
- Provide a light level sufficient for performing basic kitchen tasks such as preparing meals and washing dishes.
- Be controlled on a readily accessible switch at an entrance to the kitchen (not in a cupboard or beside the kitchen sink).
- Be switched separately from incandescent lighting and on a control panel at an entrance to the kitchen.
- Not contain medium-base incandescent lamp sockets. This prevents the occupant from replacing the efficient light source with an incandescent bulb.

To clearly demonstrate compliance with the Standards to a building department, a lighting layout design that includes a point-by-point illuminance grid for the high-efficacy lighting may be provided. To do this properly, this grid must account for the room geometry, fixture placement, coefficient of utilization (CU) of the fixtures, lamp lumens, lamp lumen depreciation, and reflectivity of all of the surfaces in the kitchen.

Table 2-5 – Typical Efficacy of Luminairies

Light Source	Type	Rated Lamp (Watts)	Typical Efficacy (Lumens / Watt)[1]
Incandescent	Standard	40 - 100	14 - 18
Incandescent	Halogen	40 - 250	20[2]
Incandescent	Halogen IR	See footnote [3]	Up to 30
Fluorescent (Lamp/ Ballast Systems)[4]	Full-Size, 4' Long	32 - 40	69 - 91
	U-Shaped T-8 Bipin	16 - 31	78 - 90
	Compact Fluorescent	5 - 9	26 - 38
	Compact Fluorescent	13 +	42 - 58
Metal Halide	Metal Halide	32 - 175	50 - 90
High Pressure Sodium	White High Pressure Sodium	35 - 100	36 - 55

1 Includes power consumed by ballasts where applicable.

2 Halogen capsule incandescent lamps may be the most efficient light source for highlighting applications. Most halogen lamps are designed to produce a beam of directed light. Manufacturer's data typically list the "candlepower" intensity of that beam, rather than lumens (lumens measure total light output in all directions).

3 A new technology using infrared reflecting films on the halogen capsules has increased output up to 30 lumens/watt for some high wattage lamps.

4 Efficacy of fluorescent lighting varies depending on lamp and ballast types.

Example 2-9 – Lighting Requirements for Kitchen

Question

Would one fluorescent light in a kitchen, installed over the sink or under one cabinet, meet the "general lighting" requirements?

Answer

No. The general lighting must evenly light the entire kitchen. Two *examples* of acceptable lighting configurations are (1) fluorescent lighting (or other light source with at least 40-lumens/watt) around the perimeter of the kitchen (under or over cabinets), or (2) a fluorescent in the center of the kitchen.

Example 2-10 – Light Sources, Other than Fluorescents

Question

If a customer asks me not to install fluorescent lights in their home, are there any other light sources I can use to meet the kitchen lighting requirements?

Answer

Yes, although they may not be readily available, there are products other than fluorescent that meet the lighting requirements of the standards, §150(k). The two criteria for the kitchen and bathroom general lighting are (1) a lamp with an efficacy of 40 lumens/watt or more, and (2) the fixtures cannot contain a medium base incandescent lamp socket. Table 2-2 indicates the typical lumens/watt of several common products, some of which meet the required lumens/watt. Specifications from a product's manufacturer can also be used to verify that a product has at least 40 lumens/watt.

Example 2-11 – Energy-efficient Kitchen Lighting, General

Question

I want to design and provide an energy efficient kitchen. I especially want the lighting design to provide an aesthetically pleasing appearance, sufficient light for basic kitchen tasks, and be energy efficient while also complying with the Energy Efficiency Standards. What is the recommended practice for achieving this goal?

Answer

It is *recommended* that the builder use one of the following four ways to show compliance:

1. Design and install only high-efficacy luminaires in the kitchen. This scenario meets the code requirement in the most straightforward manner. When kitchen lighting includes both high-efficacy sources and low-efficacy sources, the design may not meet these requirements. The second through fourth ways of showing compliance apply to kitchens with both high- and low-efficacy sources.
2. Provide at least 1.2 Watts per square foot (total square feet of the accessible kitchen floor and countertop areas) of light from high-efficacy sources, and ensure that, in the judgment of the building department plan checker, the lamps in those fixtures produce a substantially uniform pattern of lighting on kitchen work surfaces (please note that this is not a code requirement but a recommendation).
3. Make sure that at least 50 percent of the kitchen lighting wattage is high-efficacy, and that, in the judgment of the building department plan checker, the lamps in those fixtures produce a substantially uniform pattern of lighting on kitchen work surfaces (please note that this is not a code requirement but a recommendation).
4. If you wish to be certain you have provided an "energy efficient kitchen…an aesthetically pleasing appearance…sufficient light for basic kitchen tasks…while also complying with the Energy Efficiency Standards," it is recommended that you use the same procedures used by professional lighting designers (again, the intent of this recommendation is not that these procedures become a standard part of builder submittals, but rather that they are used to provide the best possible solutions for builders who wish to provide high quality lighting designs).

These procedures account for the characteristics of the room and the design and location of the specific high-efficacy luminaires that will be installed as the best method to determine if there is both sufficient and uniform light. A recognized lighting authority, the Illuminating Engineers Society (IES), provides guidelines for good lighting design in their Lighting Handbook, Reference & Application, 10th Edition.

IES guidelines recommend that at least 30 footcandles of light be provided for seeing tasks in kitchens. To clearly demonstrate compliance with the Standards to a building department, the builder may provide a lighting layout design that includes a point-by-point illuminance grid for the high-efficacy lighting. To do this

properly, this grid must account for the room geometry, fixture placement, coefficient of utilization (CU) of the fixtures, lamp lumens, lamp lumen depreciation, and reflectivity of all of the surfaces in the kitchen. Uniform lighting assures that the minimum amount of light is available on all the work surfaces used in meal preparation and cleanup. Although the design should achieve 30 footcandles on most counter-height, horizontal work surfaces, there may be a few work-surfaces where the lighting levels fall below this value and the fronts of kitchen cabinets may also be below this value. Even in these locations, the lighting level provided by the high-efficacy source should not fall below the IES-recommended lower value for non-critical seeing tasks of 20 footcandles. Parts of counters that are not work surfaces, such as a corner underneath a cabinet, may have a lighting level below 20 footcandles and still meet the requirements of the standard, because meal preparation is unlikely to occur in those areas.
Manufacturers and lighting fixture representatives can often provide such a grid for a specified design. Electrical engineers who do lighting designs and professional lighting designers also often provide designs with a point-by-point illuminance grid.
The plans should identify the type of luminaire and maximum Underwriters Laboratory (UL)-rated lamp watts for each luminaire and should include dimensions and tolerances of each luminaire so that the installer, plan checker, and field inspector can all determine when the lighting installation matches the plan checker's judgment. When calculating the kitchen lighting wattage, the builder should be certain to use the maximum UL-rated wattage for each fixture.

Bathroom Lighting


§150(k)2 - 3

2. Each room containing a shower or bathtub shall have at least one luminaire with lamp(s) with an efficacy of 40 lumens per watt or greater. If there is more than one luminaire in the room, the high efficacy luminaire shall be switched at an entrance to the room.

ALTERNATIVE to Section 150(k)2.: A high efficacy luminaire need not be installed in a bathroom if:

A. A luminaire with lamps with an efficacy of 40 lumens per watt or greater is installed in a utility room, laundry room, or garage; and

B. All luminaires permanently mounted to the residence providing outdoor lighting shall be installed with the following characteristics:

(1) Luminaires with lamps with 40 lumens per watt or greater; or

(2) Luminaires with lamps with an efficacy of less than 40 lumens per watt shall be equipped with a motion sensor.

***Note:** When using this alternative for multiple bathrooms, after complying with B. for the first bathroom, each additional bathroom in which a high efficacy luminaire is not installed must comply with A. alone.*

3. Luminaires installed to meet the 40 lumens per watt requirements of Section 150(k) 1. or 2. shall not contain medium base incandescent lamp sockets, and shall be on separate switches from any incandescent lighting.

Each room with a shower or bathtub must have at least one luminaire with lamps with an efficacy of at least 40 lumens/watt.
If there is more than one luminaire in the room, the high-efficacy luminaire must be switched at an entrance to the room.

As an alternative, both of the following are required:

1. A luminaire with 40 lumens/watt lamps must be installed in another room with utilitarian functions such as a laundry room, utility room or garage; and

2. All permanently mounted outside lighting must either be at least 40 lumens/watt or equipped with a motion sensor.

When using this alternative for two or more rooms with showers or bathtubs, compliance with item 1. above is sufficient for the second or third rooms since the outside lighting is already in compliance with item 2 above.
Luminaires installed to meet the 40 lumens/watt requirements cannot contain medium base incandescent lamp sockets, and must be on separate switches from incandescent lighting.
Incandescent lighting fixtures recessed into insulated ceilings must be approved for zero-clearance insulation cover (IC-rated) in compliance with §150(k)4 (see below).

Installing energy-efficient lamps and fixtures can reduce lighting energy costs without sacrificing the quality or quantity of light available. As indicated in Table 2-2, a 40 watt standard fluorescent lamp is over four times as efficient as a 100 watt standard incandescent lamp.

Each room with a shower or bathtub (no requirement in a half-bath) must have at least one luminaire with lamps with an efficacy of at least 40 lumens/watt, which may be fluorescent or another efficient technology (see Table 2-2 above).

When there is more than one luminaire in the room, the high-efficacy luminaire (greater than or equal to 40 lumens/watt) must be switched at an entrance to the room.

As an alternative, both of the following are required:

1. A luminaire with 40 lumens/watt lamps must be installed in a laundry room, utility room or garage; and
2. All permanently mounted outside lighting must either be at least 40 lumens/watt or equipped with a motion sensor.

Luminaires installed to meet the 40 lumens/watt requirements cannot contain medium base incandescent lamp sockets, and must be on separate switches from incandescent lighting.

Incandescent lighting fixtures recessed into insulated ceilings must be IC-rated in compliance with §150(k)4 (see Example 2-13).

Example 2-12 – No Fluorescent Lights in Bathroom and Kitchen

Question

If a customer asks me not to install fluorescent lights in their home, are there any other light sources I can use to meet the bathroom and kitchen lighting requirements?

Answer

Yes, although they may not be readily available, there are products other than fluorescent that meet the lighting requirements of the standards, §150(k). The two criteria for the kitchen and bathroom general lighting are (1) a lamp with an efficacy of 40 lumens/watt or more, and (2) the fixtures cannot contain a medium base incandescent lamp socket. Table 2-5 indicates the typical lumens/watt of several common products, some of which meet the required lumens/watt. Specifications from a product's manufacturer can also be used to verify that a product has at least 40 lumens/watt.